Sandia National Laboratories/New Mexico

PROPOSAL FOR
RISK-BASED NO FURTHER ACTION
ENVIRONMENTAL RESTORATION SITE 89
SHOCK TUBE SITE
OPERABLE UNIT 1335

August 1997

Environmental
Restoration
Project

United States Department of Energy
Albuquerque Operations Office

PROPOSAL FOR RISK-BASED NO FURTHER ACTION ENVIRONMENTAL RESTORATION SITE 89 SHOCK TUBE SITE OPERABLE UNIT 1335 August 1997

Prepared by
Sandia National Laboratories/New Mexico
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Albuquerque, New Mexico

Prepared for
the U. S. Department of Energy

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ACRONYMS AND ABBREVIATIONS

ARCOC	Analytical Request/Chain of Custody
bgs	below ground surface
CAB	cellulose acetate butyrate
CEARP	Comprehensive Environmental Assessment and Response Program
COC	constituents of concern
DOE	Department of Energy
DOU	Document of Understanding
DU	depleted uranium
DV1	Data Verification/Validation Level 1
DV2	Data Verification/Validation Level 2
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
ER	Environmental Restoration
ES&H	environmental safety and health
GPS	global positioning system
HE	high explosive
HMX	cyclotetramethylene tetranitramine
HPLC	high performance liquid chromatography
ICP	inductively couple plasma
KAFB	Kirtland Air Force Base
MDL	method detection limit
ml	milliliter
NFA	No Further Action
NMED	New Mexico Environmental Department
OU	operable unit
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RDX	hexahydro-1,3,5-trinitro-1,3,5-trazine
RPO	Radiation Protection Operations
SMO	Sample Management Office
SNL/NM	Sandia National Laboratories/New Mexico
SWMU	Solid Waste Management Unit
TAL	target analyte list
TOP	Technical Operating Procedures
TNT	2,4,6-trinitrotoluene
UXO	unexploded ordnance
VOC	volatile organic compounds

1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a No Further Action (NFA) determination for Environmental Restoration (ER) Site 89 based on risk-based analysis with confirmatory sampling (NFA Criterion 5 of the ER Document of Understanding (DOU), NMED 1996).

1.1 Description of ER Site 89

ER Site 89 is the Shock Tube Site, and is included in Operable Unit (OU) 1335 (Southwest Test Area). The site is located in the South Thunder Range, 1.6 miles west of the Solar Tower Facility and 0.6 mile southeast of Technical Area III, south of Magazine Road (Figure 1-1). The site is approximately 2.3 acres in size.

The terrain is generally flat with a gentle slope to the west and a shallow arroyo several hundred feet to the south. Vegetation consists predominantly of grasses including grama, muhly, dropseed, and galleta. Shrubs commonly associated with the grasslands include sand sage, winter fat, saltbrush, and rabbitbush. Cacti are common, and include cholla, pincushion, strawberry, and prickly pear.

Site 89 lies on the western margin of the Sandia Fault Zone at an elevation of 5,423 feet above mean sea level. The geologic materials underlying the site consist of thick alluvial sediments that overlie deep bedrock. An alluvial fan and piedmont colluvium overlies the Santa Fe Group Strata.

Soil surveys and surficial mapping provide general soil characteristics for the area around the site. The dominant soil groups in the area include the Wink-fine sandy loam, and the Tijeras gravelly fine sandy loam. No perennial surface-water bodies are present in the immediate vicinity of the site.

Depth to groundwater is approximately 480 feet below ground surface (bgs) based on monitoring well CWL MW-5, located at the Chemical Waste Landfill, approximately 2,000 feet north of the site.

A detailed review of the local and regional settings for Site 89 is documented in the "RCRA [Resource Conservation and Recovery Act] Facility Investigation [RFI] Work Plan for Operable Unit 1335, Southwest Test Area" (SNL/NM 1996) and the Site-Wide Hydrogeologic Characterization Project 1994 Annual Report (SNL/NM 1995).

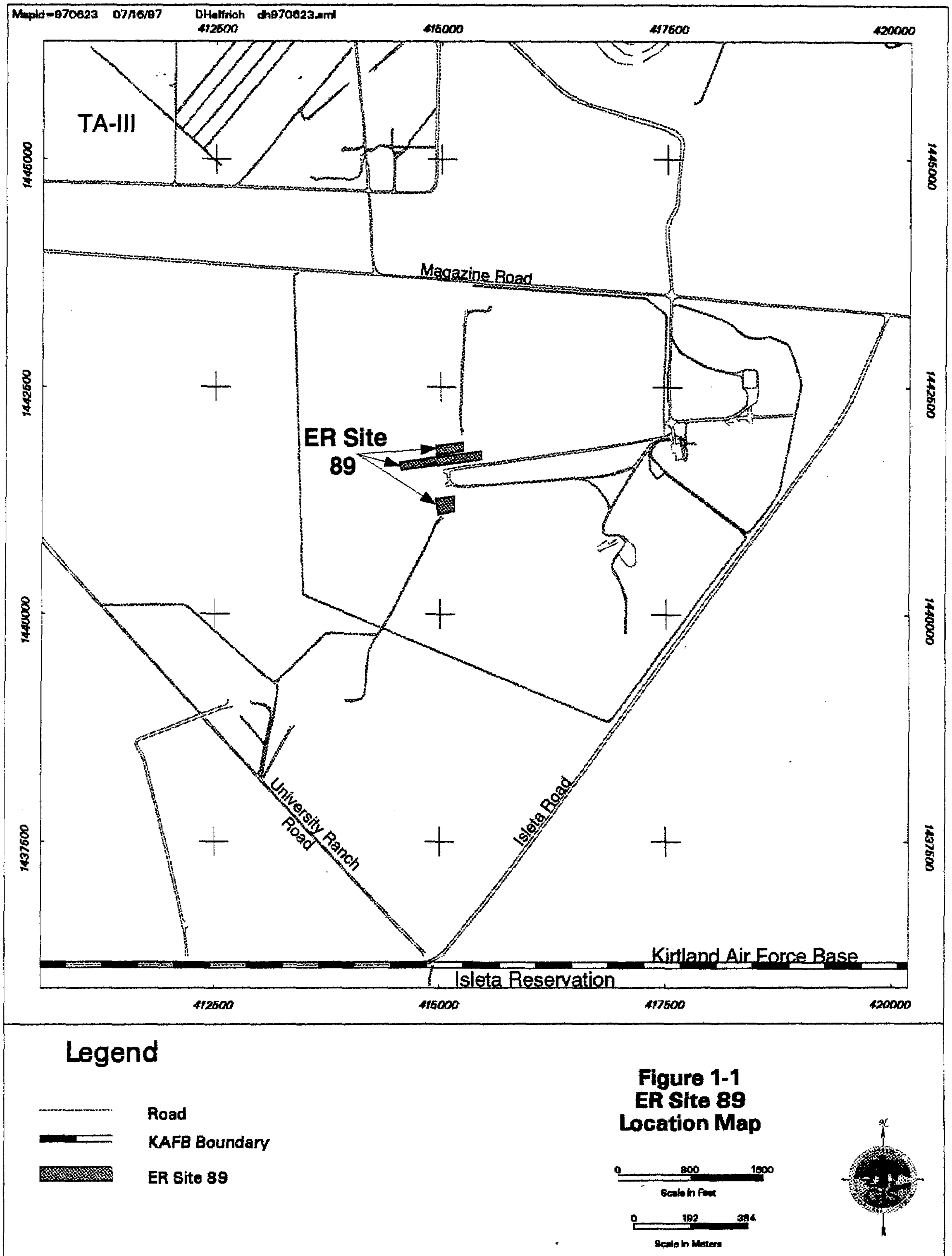

Figure 1-1
ER Site 89
Location Map

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

1.2 No Further Action Basis

Review and analysis of all relevant data for ER Site 89 indicate that concentrations of constituents of concern (COC) at the site are less than (1) SNL/NM or other applicable background limits, or (2) proposed Subpart S or other action levels, or (3) applicable risk assessment action levels. Thus, ER Site 89 is being proposed for an NFA decision based on confirmatory sampling data demonstrating that COCs that may have been released from this solid waste management unit (SWMU) into the environment pose an acceptable level of risk under current and projected future land use, per NFA Criterion 5 of the ER DOU (NMED 1996).

2.0 HISTORY OF ER SITE 89

This section provides a summary of the historical information that has been obtained at the site.

2.1 Historical Operations

In 1962, the site was established in Thunder Range to support blast testing of weapon re-entry vehicles. The site was the location of the shock tube blast tests. Blast testing consisted of detonating an uncased explosive charge at one end of a tube to create an air blast wave that sweeps over a target vehicle located at the tube's other end. This blast wave creates the desired pressure loading on the target. The shock tube focuses the blast air flow, creating high blast pressures from a relatively small quantity of explosives to simulate the shock from a nuclear blast.

Many of the shock tubes were equipped with a driver section. The driver section was a unit that covered the end of the shock tube where the charge was detonated to direct the force of the explosion down the tube to the test vehicle and not out the rear of the tube. There were two types of driver sections: an expendable water-tamped section and a non-expendable concrete driver section (SNL/NM 1994b; Ref. 663). The expendable water-tamped section consisted of a tank of water, usually about 10,000 gallons. This absorbed the force of the shock of the explosion to the rear of the tube, and was usually destroyed. The non-expendable section consisted of a large concrete block that covered the rear of the shock tube and deflected and absorbed the shock of the explosion to the rear of the tube. This section was not destroyed, and could be reused. The non-expendable driver section also prevented the release of the explosion gases out this end of the tube.

Unlined catch pits filled with sawdust or vermiculite were constructed at the far end of the shock tubes to provide a retrieval area for the test vehicle if it was ejected from the shock tube by the explosion. The test vehicle was typically a weapon re-entry vehicle where a small quantity of depleted uranium served as a surrogate for plutonium in the weapons component of the vehicle.

Non-destructive, vulnerability tests were conducted on re-entry vehicles to prove they could survive a given shock level (SNL/NM 1994b; Ref. 663). The tests were designed so the test vehicle would not be destroyed. The test units might bend or break up into large pieces but would not fragment into small pieces (SNL/NM 1994b; Refs. 517, 520). The intent was to retrieve intact test vehicles to study shock effects on certain components within the re-entry vehicles (SNL/NM 1994b; Ref. 663).

The explosive charges used in these tests were uncased. After each test, workers were required to look for uncombusted explosives. None were reportedly found, except for one small mass of aluminum nitrate (iramite), which is an ammonium compound (SNL/NM 1994b; Ref. 517).

The site was operational from 1962 through the mid-1980s. The site went through several phases of construction and test activities during this time period. The South Thunder Range facility was constructed in 1965 and was originally equipped with eight expendable plywood shock tubes. These tubes were destroyed by the tests. Range improvements lead to the construction of five reusable metal shock tubes. A discussion of these different phases is as follows:

- The eight original shock tubes were constructed with expendable (plywood) materials (SNL/NM 1994b; Ref. 292). The tube sizes varied from 2 to 8 feet in diameter. The two largest tubes were 8 feet by 100 feet long and used 4,000 pounds of Composition B explosive for each shot (total of two). The test vehicles were recovered after each test. The six smaller tubes used 60 pounds of Composition B for each test.

In the early 1960s, the expendable tubes were replaced with reusable steel tubes: a 6-foot diameter by 50-foot tube (XT-8), a 6-foot diameter by 200-foot tube (XT-9), and a 2-foot diameter by 200-foot tube (XT-10) (Figure 2-1).

- The XT-8 was a non-expendable steel tube used for testing Mk-12 re-entry vehicles. The tube was equipped with an expendable water-tamped driver section. An uncased charge of 500 pounds of concentrated explosives, probably 2,4,6-trinitrotoluene (TNT), cyclotetramethylene tetranitramine (HMX), and hexahydro-1,3-5-trinitro-1,3,5-trazine (RDX) derivative, was placed inside the tube where it was sealed at one end by the driver plate. A total of 2,500 pounds of explosives may have been detonated during five tests conducted in this tube (SNL/NM, 1994b; Refs. 292, 663).

- The XT-9 was a non-expendable steel tube used for testing Air Force Mk-21 and Mk-12a and Navy Mk-3, Mk-4, and Mk-5 re-entry vehicles The explosives used for testing were gas mixtures or primacord (or C-4). An explosive charge (maximum 500 pounds per test) was placed just inside one end of the shock tube, and the re-entry vehicle was discharged into a catch pit. A total of 15,000 pounds of explosives were estimated to have been discharged from this tube.

- The XT-10 was originally located near Building 9964 at the Beryllium Firing Site (ER Site 90). The XT-10 was relocated to Site 89 and was later combined with the 19-foot diameter tube described below. This tube was designed to perform tests on scale models. The XT-10 was constructed with flanged Schedule 40 and 80 pipe. The explosives used for each test were PETN, primacord, and concentrated or explosive gas (SNL/NM 1994b; Ref. 292). A total of 1,750 pounds of explosives were estimated to have been discharged in this tube.

- Additionally, a 19-by 65-foot shock tube was constructed and operational from 1969 to 1975 for testing Sprint Interceptor re-entry vehicles (SNL/NM 1994b; Refs. 297, 663). The number of tests and the amount of explosives used is unknown.

From 1975 to 1981 the shock tube testing program was suspended. The shock tube equipment was not used and was abandoned in place during this time period. Testing resumed in 1982.

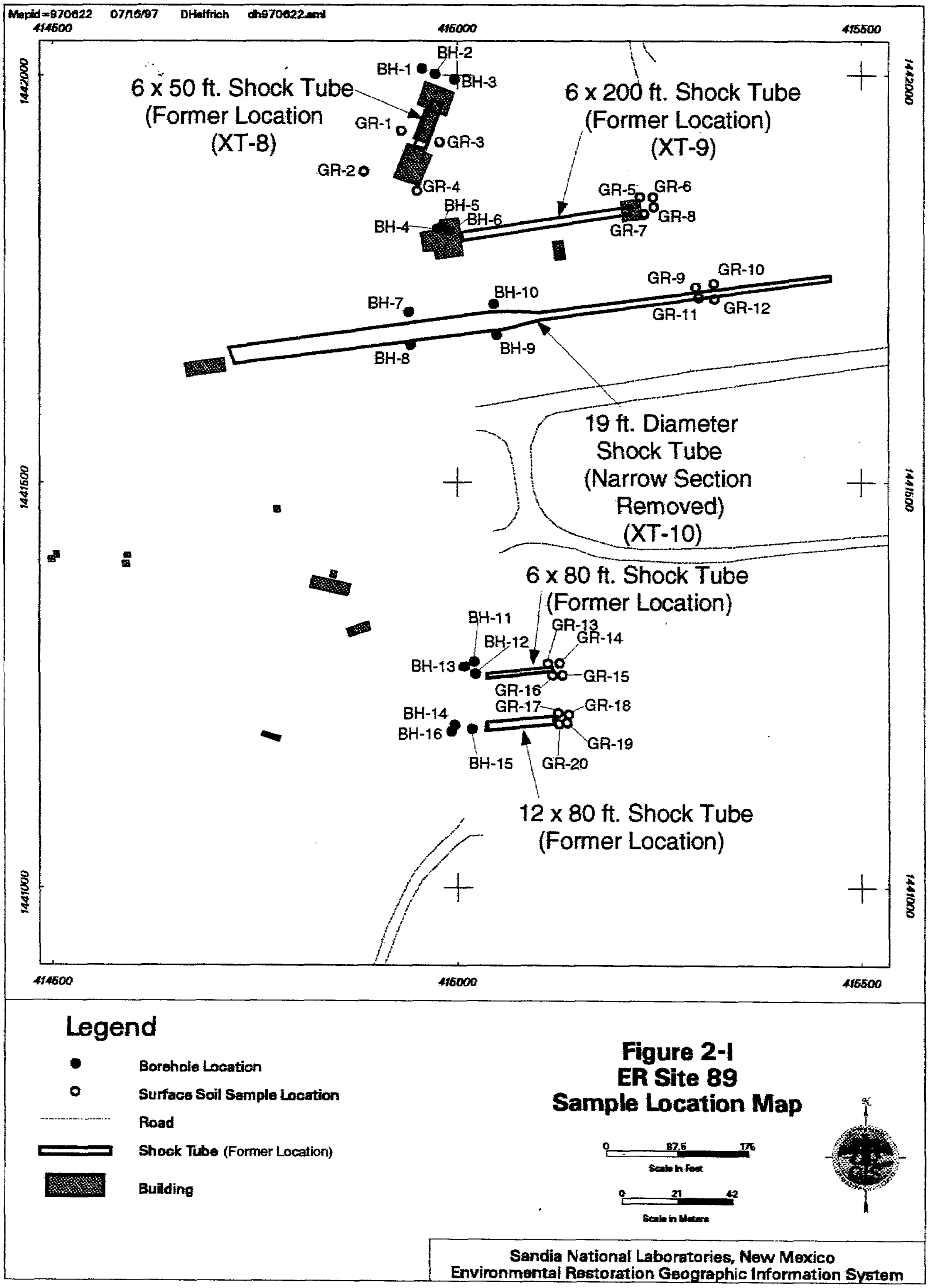

Figure 2-I
ER Site 89
Sample Location Map

- With the resumption of testing, the 19-foot diameter tube was lengthened from 65 to 580 feet. Thirty shots were fired through the tube. Explosive charge weight varied from 100 to 1,100 pounds, with an average of 200 pounds per shot. The estimated total amount of explosives (PETN) used was 6,000 pounds (SNL/NM 1994b; Refs. 297, 517).

- A 6-by 80-foot steel shock tube (Figure 2-1) was constructed after 1982 to test the Mk-21, the Trident 2, and the Mk-5 re-entry vehicles (SNL/NM 1994b; Ref. 297). A C-4 explosive charge (200 pounds) set up outside the tube was detonated for each test. A total of 1,600 pounds of C-4 explosive was estimated to have been used during eight tests.

- A 12-by 80-foot non-expendable blast tube (Figure 2-1) also was constructed in 1982. The tube was built from Space Shuttle solid booster motor cases and was used to test the hardness of interceptor motor cases (SNL/NM 1994b; Ref. 297). A C-4 explosive charge (200 pounds) set up outside the tube was detonated for each test. A total of 2,400 pounds of C-4 explosive was estimated to have been used during twelve tests.

These three testing programs were completed in 1985. No new testing has been conducted at this site since the completion of these programs. The stock tubes were dismantled by 1995 except for the 19 foot diameter section.

2.2 Previous Audits, Inspections, and Findings

The site was first listed as a potential SWMU by the "Comprehensive Environmental Assessment and Response Program, Phase I: Installation Assessment, Sandia National Laboratories, Albuquerque, New Mexico" [Draft] (DOE 1987). The listing resulted from information collected during the Phase I interviews, which indicated the area that may have been contaminated with high explosives (HE), barium, lead, beryllium, or depleted uranium (DU). In addition, pieces of shrapnel and explosives may have been left in the soil at the test sites.

3.0 EVALUATION OF RELEVANT EVIDENCE

The following sections discuss the recent field investigations, the analytical results associated with the field activities, and the human health and ecological risk assessments.

3.1 Unit Characteristics and Operating Practices

The testing involved detonating explosives (at one end of the tube) and retrieving the re-entry vehicles (at the other end of the tube) from catch basins. After each test, workers were required (as a safety procedure) to look for uncombusted explosives on the ground at the exhaust end of the shock tubes. This safety step was followed to remove any material that may have discharged from the tube due to incomplete combustion. Because of the design of the charges and because all the detonations were above grade and uncased, all the explosives were completely combusted except for a small mass of aluminum-nitrate (iramite, an ammonium compound) found after one of the tests at the 19-foot diameter shock tube (SNL/NM 1994b; Ref. 517). The iramite was removed from the site. All vehicles were recovered and removed from the site.

After the testing programs were completed in 1985, the site was abandoned. By 1995, all the shock tubes had been dismantled and removed from the site except for one section (approximately 270 feet) of the 19-foot diameter tube. In addition, some of the catch basins, concrete pads, and metal brackets remain in place.

Hazardous wastes were not managed or contained at ER Site 89.

3.2 Results of SNL/NM ER Project Sampling/Surveys

The following summary of the ER Site 89 field investigations and the evaluation of the data collected and analyzed from those investigations provide the basis for recommending 1ER Site 89 for an NFA under DOU Criterion 5 (NMED 1996).

3.2.1 Summary of Prior Investigations

The following sources of information, presented in chronological order, were used to evaluate ER Site 89:

- Unexploded Ordnance/High Explosives (UXO/HE) Visual Survey of ER Sites, Final Report (SNL/NM 1994c).
- Cultural Resource Investigation for Sandia National Laboratories/New Mexico, Environmental Restoration Program, Kirtland Air Force Base, New Mexico, February 1995 (Hoagland and Dello-Russo 1995).

- Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico, U. S. Department of Energy, Kirtland Area Office, March 1996 (DOE 1996a).

- RCRA Facility Investigation Work Plan for Operable Unit 1335, Southwest Test Area, March 1996 (SNL/NM 1996).

3.2.2 UXO/HE Survey

UXO visual surface survey was performed by the Kirtland Air Force Base explosive ordnance disposal personnel on November 15, 1993. No live UXO/HE and/or significant UXO/HE debris was found at the site (SNL/NM 1994c). No additional investigation and survey was conducted at this site.

3.2.3 Cultural Resource Survey

A cultural resources survey was completed at all sites within OU 1335. The survey results show no impact of cultural resources at Site 89 (Hoagland and Dello-Russo 1995).

3.2.4 Sensitive-Species Survey

A sensitive species survey was completed at all sites within OU 1335. The survey results show no impact of sensitive species at Site 89 (DOE 1996a).

3.2.5 Site 89 Field Investigation

The following subsections provide a summary of field investigation and the evaluation of the data collected and analyzed. Site 89 was discussed in Section 4.1.3.1 of the RFI Work Plan (SNL/NM 1996) as a SWMU proposed for an NFA. Site 89 was not included in the RFI Sampling and Analysis Plan. A separate sampling and analysis plan was prepared for Site 89. The objective of the field investigation was to determine the vertical and horizontal extent of possible soil contamination at the site.

There is no known contamination associated with Site 89. However, based on the types of materials used in the shock tube experiments, some of the materials including HE, metals (specifically beryllium), and DU may have been released into the surrounding soils. The potential COCs are HE, beryllium, and DU (SNL/NM 1996). In addition, RCRA metals are included on the COC list to account for unknowns in the materials released during the test.

ER Site 89 field investigation was performed from August 9, 1995, through August 11, 1995, and on August 14, 1995. The field activities included drilling soil borings, collecting surface and subsurface soil samples for chemical and radionuclide analyses, managing the waste generated during drilling, and surveying the sampling locations. Sample locations were determined through aerial photographs and direct field observation.

3.2.5.1 *Drilling Program*

The drilling program was conducted using a truck-mounted Geoprobe® drill rig. The soil borings were located at the catch basin end of each of the tubes. A total of 16 soil borings (BH-01 through BH-16) were drilled at Site 89 at the following shock tubes (Figure 2-1):

- Soil borings BH-01 through BH-03 were drilled at the north end of shock tube XT-8.
- Soil borings BH-04 through BH-06 were drilled at the west end of shock tube XT-9.
- Soil borings BH-07 through BH-10 were drilled along the north side (two borings) and south side (two borings) of the original catch basin for the 19-foot diameter tube.
- Soil borings BH-11 through BH-13 were drilled at the west end of the 6-by 80-foot shock tube.
- Soil borings BH-14 through BH-16 were drilled at the west end of the 12-by 80-foot shock tube.

All soil boring locations were surveyed with Global Positioning System (GPS) equipment. The survey data includes northing and easting coordinates for each boring.

3.2.5.2 *Subsurface and Surface Soil Sample Collection*

Subsurface soil samples were collected at 0 to 1.5 feet bgs and 8 to 9.5 feet bgs from each borehole (sample location) with a 2.5-inch outside diameter by 4-foot long core sampler that was lined with a cellulose acetate butyrate (CAB) sleeve. Upon removal of the CAB liner from the sampler, the soil was removed from the liner and placed into appropriate glass containers. Two containers were sealed with tape and prepared for shipment to the on-site laboratory for HE and target analyte list (TAL) metals analyses. When needed, one container was prepared for shipment to the off-site laboratory for HE and TAL metals analyses. The remaining sample was removed from the liner and placed in Marinelli jars for gamma spectroscopy analysis by the on-site laboratory.

Surface soil samples were also collected at each shock tube location. The sample locations were selected at the shock tube end where the uncased explosives were detonated. A total of 20 surface locations (GR-01 through GR-20) were placed at the following shock tubes (Figure 2-1):

- Surface soil samples GR-01 through GR-04 were collected at the south end of shock tube XT-8.
- Surface soil samples GR-05 through GR-08 were collected at the east end of shock tube XT-9.
- Surface soil samples GR-09 through GR-12 were collected at the east end of the 19-foot diameter shock tube.

- Surface soil sample GR-13 through GR-16 were collected at the east end of the 6-by 80-foot shock tube.
- Surface soil samples GR-17 through GR-20 were collected at the east end of the 12-by 80-foot shock tube.

Each sample was composited, placed in appropriate containers, and prepared for shipment to the same laboratories as the subsurface soil samples. All surface soil sample locations were surveyed with GPS equipment to determine northing and easting coordinates for each location.

The samples collected and the analyses performed on these samples are provided in Table 3-1. Thirty-two subsurface and twenty surface soil samples were collected and sent to the on-site laboratory for gamma spectroscopy, HE, and TAL metal analyses. Six subsurface and five surface soil samples were collected and sent to the off-site laboratory for HE and TAL metal analyses (confirmation of the on-site laboratory analyses). The data quality objective of 100 percent on-site laboratory analysis with 20 percent off-site laboratory analysis for confirmation was obtained for this site.

3.2.5.3 Sample Packaging and Shipping

Soil samples sent to the on-site laboratory for HE and TAL metal analyses were collected in 125 milliliter (ml) bottles. Soil samples sent to the on-site laboratory for gamma spectroscopy analysis were collected in 500 ml containers. The soil samples sent to the off-site laboratory for HE and TAL metal analyses were collected in 500 ml bottles.

The gamma spectroscopy (on-site laboratory) and the HE and TAL metal (off-site laboratory) samples were delivered to the SNL/NM Sample Management Office (SMO). SMO personnel performed cross-checking of the information on the sample labels against the data on the Analysis Request and Chain of Custody (ARCOC) forms, and prepared samples for shipment. The HE and TAL metal samples were shipped by overnight delivery to the Lockheed Analytical Services laboratory in Las Vegas, Nevada. The gamma spectroscopy samples were delivered to the on-site radiological laboratory on the same day as received by SMO.

The remaining HE and TAL metal samples were sent directly to the on-site laboratory for analysis.

3.2.5.4 Data Management

Data management for the off-site laboratory analytical data was coordinated through the SMO project coordinator. Upon sample shipment to the off-site laboratory, sample information was entered into a database to track the status of each sample. Upon completion of the laboratory analyses, SMO received analytical results in summary data and laboratory QC reports. The on-site laboratory analytical data was managed by the on-site laboratory manager.

TABLE 3-1
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
Surface Soil									
	8/14/95	89-GR-001-0-SS-1		X	X				
	8/14/95	89-GR-001-0-SS-2				X			
	8/14/95	89-GR-001-0-SS-3					X		
	8/14/95	89-GR-002-0-SS-1		X	X				
	8/14/95	89-GR-002-0-SS-2				X			
	8/14/95	89-GR-002-0-SS-3					X		
	8/14/95	89-GR-003-0-SS-1		X	X				
	8/14/95	89-GR-003-0-SS-2				X			
	8/14/95	89-GR-003-0-SS-3					X		
	8/14/95	89-GR-004-0-SS-1		X	X				
	8/14/95	89-GR-004-0-SS-2				X			
	8/14/95	89-GR-004-0-SS-3					X		
014959-07	8/14/95	89-GR-005-0-SSD		X	X				
	8/14/95	89-GR-005-0-SS-2				X			
	8/14/95	89-GR-005-0-SS-3					X		
014959-05	8/14/95	89-GR-005-0-SS0						X	X
	8/14/95	89-GR-006-0-SS-1		X	X				
	8/14/95	89-GR-006-0-SS-2				X			
	8/14/95	89-GR-006-0-SS-3					X		
	8/14/95	89-GR-007-0-SS-1		X	X				
	8/14/95	89-GR-007-0-SS-2				X			
	8/14/95	89-GR-007-0-SS-3					X		
	8/14/95	89-GR-008-0-SS-1		X	X				
	8/14/95	89-GR-008-0-SS-2				X			
	8/14/95	89-GR-008-0-SS-3					X		
	8/14/95	89-GR-009-0-SS-1		X	X				
	8/14/95	89-GR-009-0-SS-2				X			

TABLE 3-1 (Continued)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
	8/14/95	89-GR-009-0-SS-3					X		
1	8/14/95	89-GR-010-0-SD-8	Duplicate	X	X				
014960-07	8/14/95	89-GR-010-0-SS			X				
014960-05	8/14/95	89-GR-010-0-SSO						X	X
	8/14/95	89-GR-010-0-SS-2				X			
	8/14/95	89-GR-010-0-SS-15	Duplicate			X			
	8/14/95	89-GR-010-0-SS-3					X		
	8/14/95	89-GR-010-0-SD-4	Duplicate				X		
	8/14/95	89-GR-011-0-SS-1		X	X				
	8/14/95	89-GR-011-0-SS-2				X			
	8/14/95	89-GR-011-0-SS-3					X		
	8/14/95	89-GR-012-0-SS-1		X	X				
	8/14/95	89-GR-012-0-SS-2				X			
	8/14/95	89-GR-012-0-SS-3					X		
	8/14/95	89-GR-013-0-SS-1		X	X				
	8/14/95	89-GR-013-0-SS-2				X			
	8/14/95	89-GR-013-0-SS-3					X		
	8/14/95	89-GR-014-0-SS-1		X	X				
	8/14/95	89-GR-014-0-SS-2				X			
	8/14/95	89-GR-014-0-SS-3					X		
014961-07	8/14/95	89-GR-015-0-SSD		X	X				
	8/14/95	89-GR-015-0-SS-2				X			
	8/14/95	89-GR-015-0-SS-3					X		
014961-05	8/14/95	89-GR-015-0-SSO						X	X
	8/14/95	89-GR-016-0-SS-1		X	X				
	8/14/95	89-GR-016-0-SS-2				X			
	8/14/95	89-GR-016-0-SS-3					X		
	8/14/95	89-GR-017-0-SS-1		X	X				

TABLE 3-1 (Continued)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
	8/14/95	89-GR-017-0-SS-2				X			
	8/14/95	89-GR-017-0-SS-3					X		
	8/14/95	89-GR-018-0-SS-1		X	X				
	8/14/95	89-GR-018-0-SS-2				X			
	8/14/95	89-GR-018-0-SS-3					X		
	8/14/95	89-GR-019-0-SS-1		X	X				
	8/14/95	89-GR-019-0-SS-2				X			
	8/14/95	89-GR-019-0-SS-3					X		
014962-07	8/14/95	89-GR-020-0-SSD		X	X				
	8/14/95	89-GR-020-0-SD-08	Duplicate		X				
	8/14/95	89-GR-020-0-SS-2				X			
	8/14/95	89-GR-020-0-SS-16	Duplicate			X			
	8/14/95	89-GR-020-0-SS-3					X		
	8/14/95	89-GR-020-0-SD-18	Duplicate				X		
014962-05	8/14/95	89-GR-020-0-SS0						X	X
014962-06	8/14/95	89-GR-020-0-SS0	Duplicate					X	X
Subsurface Soil									
	8/9/95	89-BH1-0-S-1		X	X				
	8/9/95	89-BH1-0-S-2					X		
	8/9/95	89-BH1-0-S-3				X			
	8/9/95	89-BH1-8-S-1		X	X				
	8/9/95	89-BH1-8-S-2					X		
	8/9/95	89-BH1-8-S-3				X			
	8/9/95	89-BH2-0-S-1		X	X				
	8/9/95	89-BH2-0-S-2					X		
	8/9/95	89-BH2-0-S-3				X			
	8/9/95	89-BH2-8-S-1		X	X				

TABLE 3-1 (Continued)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
	8/9/95	89-BH2-8-S-2					X		
	8/9/95	89-BH2-8-S-3				X			
025342-01	8/9/95	89-BH3-0-S-1		X	X				
	8/9/95	89-BH3-0-S-2					X		
	8/9/95	89-BH3-0-S-3				X			
025342-04	8/9/95	89-BH3-0-S-4							X
025342-05	8/9/95	89-BH3-0-S-5						X	
	8/9/95	89-BH3-8-S-1		X	X				
	8/9/95	89-BH3-8-S-2					X		
	8/9/95	89-BH3-8-S-3				X			
	8/9/95	89-BH4-0-S-1		X	X				
	8/9/95	89-BH4-0-S-2					X		
	8/9/95	89-BH4-0-S-3				X			
	8/9/95	89-BH4-8-S-1		X	X				
	8/9/95	89-BH4-8-S-2					X		
	8/9/95	89-BH4-8-S-3				X			
	8/9/95	89-BH5-0-S-1		X	X				
	8/9/95	89-BH5-0-S-2					X		
	8/9/95	89-BH5-0-S-3				X			
025343-01	8/9/95	89-BH5-8-S-1		X	X				
	8/9/95	89-BH5-8-SD-1	Duplicate		X				
	8/9/95	89-BH5-8-S-2					X		
	8/9/95	89-BH5-8-SD-2	Duplicate				X		
	8/9/95	89-BH5-8-S-3				X			
	8/9/95	89-BH5-8-SD-3	Duplicate			X			
025343-04	8/9/95	89-BH5-8-S-4							X
025343-05	8/9/95	89-BH5-8-S-5						X	
	8/10/95	89-BH6-0-S-1		X	X				

TABLE 3-1 (Continued)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
	8/10/95	89-BH6-0-S-2					X		
	8/10/95	89-BH6-0-S-3				X			
	8/10/95	89-BH6-8-S-1		X	X				
	8/10/95	89-BH6-8-S-2					X		
	8/10/95	89-BH6-8-S-3				X			
	8/10/95	89-BH7-3-S-1		X	X				
	8/10/95	89-BH7-3-S-2					X		
	8/10/95	89-BH7-3-S-3				X			
	8/10/95	89-BH7-11-S-1		X	X				
	8/10/95	89-BH7-11-S-2					X		
	8/10/95	89-BH7-11-S-3				X			
025346-01	8/10/95	89-BH8-3-S-1		X	X				
	8/10/95	89-BH8-3-S-2					X		
	8/10/95	89-BH8-3-S-3				X			
025346-04	8/10/95	89-BH8-3-S-4							X
025346-05	8/10/95	89-BH8-3-S-5						X	
	8/10/95	89-BH8-11-S-1		X	X				
	8/10/95	89-BH8-11-S-2					X		
	8/10/95	89-BH8-11-S-3				X			
	8/10/95	89-BH9-3-S-1		X	X				
	8/10/95	89-BH9-3-S-2					X		
	8/10/95	89-BH9-3-S-3				X			
	8/10/95	89-BH10-3-S-1		X	X				
	8/10/95	89-BH10-3-S-2					X		
	8/10/95	89-BH10-3-S-3				X			
	8/11/95	89-BH11-0-S-1		X	X				
	8/11/95	89-BH11-0-S-2					X		
	8/11/95	89-BH11-0-S-3				X			

TABLE 3-1 (Continued)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
025349-01	8/11/95	89-BH11-8-S-1		X	X				
	8/11/95	89-BH11-8-SD-1	Duplicate	X					
	8/11/95	89-BH11-8-S-2					X		
	8/11/95	89-BH11-8-S-3				X			
	8/11/95	89-BH11-8-SD-3	Duplicate			X			
025349-04	8/11/95	89-BH11-8-S-4							X
025349-05	8/11/95	89-BH11-8-S-5						X	
	8/11/95	89-BH12-0-S-1		X	X				
	8/11/95	89-BH12-0-S-2					X		
	8/11/95	89-BH12-0-S-3				X			
	8/11/95	89-BH12-8-S-1		X	X				
	8/11/95	89-BH12-8-S-2					X		
	8/11/95	89-BH12-8-S-3				X			
	8/11/95	89-BH13-0-S-1		X	X				
	8/11/95	89-BH13-0-S-2					X		
	8/11/95	89-BH13-0-S-3				X			
	8/11/95	89-BH13-8-S-1		X	X				
	8/11/95	89-BH13-8-S-2					X		
	8/11/95	89-BH13-8-S-3				X			
025350-01	8/11/95	89-BH14-0-S-1		X	X				
	8/11/95	89-BH14-0-S-2					X		
	8/11/95	89-BH14-0-S-3				X			
025350-04	8/11/95	89-BH14-0-S-4							X
025350-05	8/11/95	89-BH14-0-S-5						X	
	8/11/95	89-BH14-8-S-1		X	X				
	8/11/95	89-BH14-8-S-2					X		
	8/11/95	89-BH14-8-S-3				X			
	8/14/95	89-BH15-0-S-1		X	X				

TABLE 3-1 (Continued)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
	8/14/95	89-BH15-0-S-2					X		
	8/14/95	89-BH15-0-S-3				X			
025353-01	8/14/95	89-BH15-8-SO-1		X	X				
	8/14/95	89-BH15-8-S-1			X				
	8/14/95	89-BH15-8-S-2					X		
	8/14/95	89-BH15-8-SD-2	Duplicate				X		
	8/14/95	89-BH15-8-S-3				X			
	8/14/95	89-BH15-8-SD-3	Duplicate			X			
025353-04	8/14/95	89-BH15-8-SO-4							X
025353-05	8/14/95	89-BH15-8-SO-5						X	
	8/14/95	89-BH16-0-S-1		X	X				
	8/14/95	89-BH16-0-S-2					X		
	8/14/95	89-BH16-0-S-3				X			
	8/14/95	89-BH16-8-S-1		X	X				
	8/14/95	89-BH16-8-S-2					X		
	8/14/95	89-BH16-8-S-3				X			
Field Blank									
025344-01	8/9/95	89-BH5-8-FB-1	Deionized Water		X				
025344-04	8/9/95	89-BH5-8-FB-4	Deionized Water						X
025344-05	8/9/95	89-BH5-8-FB-5	Deionized Water					X	
025348-01	8/10/95	89-BH9-3-FB-1	Deionized Water		X				
025348-04	8/10/95	89-BH9-3-FB-4	Deionized Water						X
025348-05	8/10/95	89-BH9-3-FB-5	Deionized Water					X	
025351-01	8/11/95	89-BH14-8-FB-1	Deionized Water		X				
025351-04	8/11/95	89-BH14-8-FB-4	Deionized Water						X
025351-05	8/11/95	89-BH14-8-FB-5	Deionized Water					X	
014963-14	8/14/95	89-GR-020-0-FB	Deionized Water		X				

TABLE 3-1 (Concluded)
ER Site 89: Listing of Samples Collected and Analysis Performed

SAMPLE NUMBER	DATE SAMPLED	SAMPLE LOCATION	REMARKS	FIELD SCREENING	ON-SITE LAB			OFF-SITE LAB	
				Radiation	Gamma spec.	High Explosives	TAL Metals	High Explosives	TAL Metals
014963-10	8/14/95	89-GR-020-0-FB	Deionized Water					X	
014963-12	8/14/95	89-GR-020-0-FB	Deionized Water						X
Equipment Blank									
025345-01	8/9/95	89-BH5-8-EB-1	Deionized Water		X				
025345-04	8/9/95	89-BH5-8-EB-4	Deionized Water						X
025345-05	8/9/95	89-BH5-8-EB-5	Deionized Water					X	
025347-01	8/10/95	89-BH9-3-EB-1	Deionized Water		X				
025347-04	8/10/95	89-BH9-3-EB-4	Deionized Water						X
025347-05	8/10/95	89-BH9-3-EB-5	Deionized Water					X	
025352-01	8/11/95	89-BH14-8-EB-1	Deionized Water		X				
025352-04	8/11/95	89-BH14-8-EB-4	Deionized Water						X
025352-05	8/11/95	89-BH14-8-EB-5	Deionized Water					X	
014963-13	8/14/95	89-GR-020-0-EB	Deionized Water		X				
014963-09	8/14/95	89-GR-020-0-EB	Deionized Water					X	
014963-11	8/14/95	89-GR-020-0-EB	Deionized Water						X

The chemical data (Certificate of Analysis) reports were reviewed by IT Corporation for completeness and accuracy as required by SNL/NM Technical Operating Procedures (TOP) 94-03 (SNL/NM 1994d). The data verification was performed using SNL/NM Data Verification/ Validation Level 1 (DV1) and Level 2 (DV2) checklists. The SMO and the on-site laboratory managers submitted the original ARCOCs, the Certificate of Analysis reports, and the DV1/DV2 review reports to the SNL/NM Environment, Safety, and Health (ES&H) Records Center.

3.2.5.5 *Analytical Data Summary*

Analytical Methods

All soil samples were field screened for radiation by the Radiation Protection Operations office. Gamma spectroscopy samples were analyzed following SNL/NM-approved analytical procedures by the on-site laboratory. Samples sent to the on-site laboratory were analyzed for metals by inductively couple plasma, for mercury by cold vapor atomic adsorption, and for HE by high performance liquid chromatography. Samples sent to the off-site laboratory were analyzed by U.S. Environmental Protection Agency (EPA) Methods 6010/7000/7471 for TAL metals and Method 8330 for HE.

Analytical results for inorganic compounds listed "J" values for some compounds. A "J" indicates an estimated value for a compound detected at a level less than the reporting limit but greater than the method detection limit. Data results flagged as "J" values are included in the data summary tables used in this report; because "J" values may represent false-positive concentrations, care should be used when evaluating these analytical results.

Surface Soil Sample Results

The analytical results for surface soil samples were as follows:

- The pancake probe readings (field screening for radiation) were within normal background levels of 80 to 120 counts per minute (Mignardot 1996). Since the readings were within background levels, no additional samples were sent to the laboratory for isotopic uranium analysis per the sampling plan.

- Gamma spectroscopy results were within normal background levels (Brown 1997). The complete analytical results and review are provided in Section 6.1.

- The on-site and off-site HE results were non-detect for all samples (including the field and equipment blank samples). The complete analytical data packages are located in the SNL/NM ES&H Records Center.

- The on-site laboratory analytical results were non-detect for the following metals: antimony, arsenic, beryllium, cadmium, cobalt, chromium, mercury, nickel, selenium, silver, and thallium. Metals detected by the on-site laboratory that are above SNL/NM background levels (Southwest Group) and/or Subpart S action levels and site COCs are summarized in Table 3-2. The off-site laboratory analytical results were non-detect for the following metals: antimony, beryllium, cadmium, cobalt, mercury, selenium, silver, sodium, and thallium. Metals detected by the off-site laboratory which are above SNL/NM background levels (Southwest Group) and/or Subpart S action levels and site COCs are summarized in Table 3-3. The complete analytical data packages are located in the SNL/NM ES&H Records Center. A complete discussion of the metal results is provided in Section 3.2.5.7.

Subsurface Soil Sample Results

The analytical results for subsurface soil samples were as follows:

- The pancake probe readings (field screening) were within normal background levels of 80 to 120 counts per minute (Mignardot 1996). Since the readings were within background levels, no additional samples were sent to the laboratory for isotopic uranium analysis per the confirmatory sampling plan.

- Gamma spectroscopy results were within normal background levels (Brown 1997). The complete analytical results and review are provided in Section 6.1.

- The on-site and off-site HE results were non-detect for all samples (including the field and equipment blank samples) except three locations. Trace amounts (less than 1 mg/kg) of RDX were detected at BH-12 from the 0 to 1.5 feet and 8 to 9.5 feet sampling intervals and at BH-13 from the 8 to 9.5 feet sampling interval. The complete analytical data packages are located in the SNL/NM ES&H Records Center.

- The on-site laboratory analytical results were non-detect for the following metals: antimony, arsenic, beryllium, cadmium, cobalt, copper, selenium, silver, and thallium. Metals detected by the on-site laboratory that are above SNL/NM background levels (Southwest Group) and/or Subpart S action levels and site COCs are summarized in Table 3-4. The off-site laboratory analytical results were non-detect for the following metals: antimony, beryllium, cadmium, cobalt, mercury, selenium, silver, sodium, and thallium. Metals detected by the off-site laboratory which are above SNL/NM background levels (Southwest Group) and/or Subpart S action levels and site COCs are summarized in Table 3-5. The complete analytical data packages are located in the SNL/NM ES&H Records Center. A complete discussion of the metal results is provided in Section 3.2.5.7.

3.2.5.6 Quality Assurance/Quality Control Results

This subsection discusses the field and laboratory quality assurance/quality control results.

TABLE 3-2
ER Site 89: Summary of TAL Metals Results for Surface Soil Samples, August 1995
(On-Site Laboratory only)

Sample Attributes			TAL Metals, Methods 6010/7010 (mg/kg)						
Sample Number	ER Sample ID	Sample Depth (in.)	Al	As	Be	Co	Cu	Pb	Tl
NA	89-GR-001-0-SS-03	0-6	5200	ND	ND	ND	ND	40	ND
NA	89-GR-002-0-SS-03	0-6	6200	ND	ND	ND	ND	19 J	ND
NA	89-GR-003-0-SS-03	0-6	6400	ND	ND	ND	ND	19 J	ND
NA	89-GR-004-0-SS-03	0-6	15000	ND	ND	ND	ND	15 J	ND
NA	89-GR-005-0-SS-03	0-6	6900	ND	ND	ND	ND	ND	ND
NA	89-GR-006-0-SS-03	0-6	6300	ND	ND	ND	ND	ND	ND
NA	89-GR-007-0-SS-03	0-6	7200	ND	ND	ND	ND	ND	ND
NA	89-GR-008-0-SS-03	0-6	3900	ND	ND	ND	23 J	ND	ND
NA	89-GR-009-0-SS-03	0-6	8700	ND	ND	ND	ND	ND	ND
NA	89-GR-010-0-SS-03	0-6	10000	ND	ND	ND	ND	12 J	ND
NA	89-GR-011-0-SS-03	0-6	7500	ND	ND	ND	ND	490	ND
NA	89-GR-012-0-SS-03	0-6	11000	ND	ND	ND	ND	ND	ND
NA	89-GR-013-0-SS-03	0-6	9300	ND	ND	ND	ND	15 J	ND
NA	89-GR-014-0-SS-03	0-6	6500	ND	ND	ND	24 J	ND	ND
Method Detection Limit			20	50	3.4	10	20	10	200
Site-Wide Background UTL/95th Percentile (Southwest Group)[a]			NA	5.6	0.65	5.2	15.4	21.4	<1.1

TABLE 3-2 (Concluded)
ER Site 89: Summary of TAL Metals Results for Surface Soil Samples, August 1995
(On-Site Laboratory only)

Sample Attributes			TAL Metals, Methods 6010/7010 (mg/kg)						
Sample Number	ER Sample ID	Sample Depth (in.)	Al	As	Be	Co	Cu	Pb	Tl
NA	89-GR-015-0-SS-03	0-6	6800	ND	ND	ND	ND	48	ND
NA	89-GR-016-0-SS-03	0-6	7800	ND	ND	ND	ND	ND	ND
NA	89-GR-017-0-SS-03	0-6	7500	ND	ND	ND	ND	ND	ND
NA	89-GR-018-0-SS-03	0-6	5800	ND	ND	ND	ND	ND	ND
NA	89-GR-019-0-SS-03	0-6	8700	ND	ND	ND	ND	ND	ND
NA	89-GR-020-0-SS-03	0-6	6800	ND	ND	ND	ND	ND	ND
NA	89-GR-020-0-SD-04	0-6	5600	ND	ND	ND	ND	ND	ND
Method Detection Limit			20	50	3.4	10	20	10	200
Site-Wide Background UTL/95th Percentile (Southwest Group)[a]			NA	5.6	0.65	5.2	15.4	21.4	<1.1

[a]UTL/95th Percentile values taken from SNL/NM sitewide background report (IT Corporation 1996b).

Notes: **mg/kg** - milligrams per kilogram; **J** - concentration below the practical quantitation limit; **ND** - not detected at the method detection limit; **NA** - not applicable; **TAL** - target analyte list; **UTL** - upper tolerance limit.

Metals: **Al** - aluminum; **As** - arsenic; **Be** - beryllium; **Co** - cobalt; **Cu** - copper; **Pb** - lead; **Tl** - Thallium

TABLE 3-3
ER Site 89: Summary of TAL Metals Results for Surface Soil Samples, August 1995 (Off-Site Laboratory only)

Sample Attributes			TAL Metals, Methods 6010/7010 (mg/kg)						
Sample Number	ER Sample ID	Sample Depth (in.)	Al	As	Be	Cr	Co	Cu	Tl
014959-05	89-GR-005-0-SSO	0-6	14000	4.6	<1.0	15	<10	12	<2.0
014960-05	89-GR-010-0-SSO	0-6	22000	6.4	<1.0	21	<10	14	<2.0
014961-05	89-GR-015-0-SSO	0-6	14000	3.6	<1.0	13	<10	36	<2.1
014962-05	89-GR-020-0-SSO	0-6	9900	2.9	<1.0	10	<10	7.7	<2.1
014962-06	89-GR-020-0-SSOD	0-6	9400	3.5	<1.0	11	<10	7.4	<2.0
Practical Quantitation Limit			41	2.0-2.1	1	2.0-2.1	10	5.0-5.2	2.0-2.1
Site-Wide Background UTL/95th Percentile (Southwest Group)[a]			NA	5.6	0.65	17.3	5.2	15.4	<1.1
Quality Assurance/Quality Control Samples (mg/l)									
014963-11	89-GR-020-0-EB	NA	0.91	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
014963-12	89-GR-020-0-FB	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
Practical Quantitation Limit			0.2	0.01	0.005	0.01	0.05	0.025	0.01

[a]UTL/95th Percentile values taken from SNL/NM sitewide background report (IT Corporation 1996b).

Notes: mg/kg - milligrams per kilograms; **mg/l** - milligrams per liter; **B** - detected in the laboratory method blank; **J** - concentration below the practical quantitation limit; **ND** - not detected at the method detection limit; **NA** - not applicable; **TAL** = target analyte list; **UTL** - upper tolerance limit.

Metals: Al - aluminum; **As** - arsenic; **Be** - beryllium; **Cr** - chromium; **Co** - cobalt; **Cu** - copper; **Tl** - thallium.

TABLE 3-4
ER Site 89: Summary of TAL Metals Results for Subsurface Soil Samples, August 1995
(On-Site Laboratory only)

Sample Attributes			TAL Metals, Methods 6010/7010 (mg/kg)						
Sample Number	ER Sample ID	Sample Depth (ft.)	Al	As	Be	Cr	Co	Cu	Tl
NA	89-BH01-0-S-2	0-1.5	6300	ND	ND	ND	ND	ND	ND
NA	89-BH01-8-S-2	8-9.5	3700	ND	ND	ND	ND	ND	ND
NA	89-BH02-0-S-2	0-1.5	7700	ND	ND	ND	ND	ND	ND
NA	89-BH02-8-S-2	8-9.5	7800	ND	ND	ND	ND	ND	ND
NA	89-BH03-0-S-2	0-1.5	6200	ND	ND	ND	ND	ND	ND
NA	89-BH03-8-S-2	8-9.5	3800	ND	ND	ND	ND	ND	ND
NA	89-BH04-0-S-2	0-1.5	6900	ND	ND	ND	ND	ND	ND
NA	89-BH04-8-S-2	8-9.5	3200	ND	ND	ND	ND	ND	ND
NA	89-BH05-0-S-2	0-1.5	8600	ND	ND	ND	ND	ND	ND
NA	89-BH05-8-S-2	8-9.5	3900	ND	ND	ND	ND	ND	ND
NA	89-BH05-8-SD-2	8-9.5	3700	ND	ND	ND	ND	ND	ND
NA	89-BH06-0-S-2	0-1.5	6000	ND	ND	ND	ND	ND	ND
NA	89-BH06-8-S-2	8-9.5	2600	ND	ND	ND	ND	ND	ND
NA	89-BH07-03-S-2	3-4.5	4700	ND	ND	ND	ND	ND	ND
NA	89-BH07-11-S-2	11-12.5	3400	ND	ND	ND	ND	ND	ND
NA	89-BH08-03-S-2	3-4.5	6100	ND	ND	ND	ND	ND	ND
NA	89-BH08-11-S-2	11-12.5	2900	ND	ND	ND	ND	ND	ND
NA	89-BH09-03-S-2	3-4.5	5800	ND	ND	ND	ND	ND	ND
NA	89-BH10-3-S-2	3-4.5	8800	ND	ND	ND	ND	ND	ND
NA	89-BH11-0-S-2	0-1.5	7100	ND	ND	ND	ND	ND	ND
NA	89-BH11-8-S-2	8-9.5	3200	ND	ND	ND	ND	ND	ND
NA	89-BH11-8-SD-2	8-9.5	3600	ND	ND	ND	ND	ND	ND
NA	89-BH12-0-S-2	0-1.5	4700	ND	ND	ND	ND	ND	ND
NA	89-BH12-8-S-2	8-9.5	4000	ND	ND	ND	ND	ND	ND
Method Detection Limit			20	50	3.4	10	10	20	200
Site-Wide Background UTL/95th Percentile (Southwest Group)[a]			NA	4.4	0.65	15.9	5.2	18.2	<1.1

TABLE 3-4 (Concluded)
ER Site 89: Summary of TAL Metals Results for Subsurface Soil Samples, August 1995
(On-Site Laboratory only)

Sample Attributes			TAL Metals, Methods 6010/7010 (mg/kg)						
Sample Number	ER Sample ID	Sample Depth (ft.)	Al	As	Be	Cr	Co	Cu	Tl
NA	89-BH13-0-S-2	0-1.5	6400	ND	ND	ND	ND	ND	ND
NA	89-BH13-8-S-2	8-9.5	4600	ND	ND	ND	ND	ND	ND
NA	89-BH14-0-S-2	0-1.5	3400	ND	ND	ND	ND	ND	ND
NA	89-BH14-8-S-2	8-9.5	1800	ND	ND	ND	ND	ND	ND
NA	89-BH15-0-S-2	0-1.5	10000	ND	ND	81	ND	ND	ND
NA	89-BH15-8-S-2	8-9.5	3600	ND	ND	ND	ND	ND	ND
NA	89-BH15-8-SD-2	8-9.5	3600	ND	ND	ND	ND	ND	ND
NA	89-BH16-0-S-2	0-1.5	8200	ND	ND	54	ND	ND	ND
NA	89-BH16-8-S-2	8-9.5	5400	ND	ND	23 J	ND	ND	ND
Method Detection Limit			20	50	3.4	10	10	20	200
Site-Wide Background UTL/95th Percentile (Southwest Group)[a]			NA	4.4	0.65	15.9	5.2	18.2	<1.1

[a]UTL/95th Percentile values taken from SNL/NM sitewide background report (IT Corporation 1996b).

Notes: J - concentration below the practical quantitation limit; **ND** - not detected at the method detection limit; **NA** - not applicable; **UTL** - upper tolerance limit.

Metals: Al - aluminum; **As** - arsenic; **Be** - beryllium; **Cr** - chromium; **Co** - cobalt; **Cu** - copper; **Tl** - thallium

TABLE 3-5
ER Site 89: Summary of TAL Metals Results for Subsurface Soil Samples, August 1995
(Off-Site Laboratory only)

Sample Attributes			TAL Metals, Methods 6010 (mg/kg)						
Sample Number	**ER Sample ID**	**Sample Depth (ft.)**	**Al**	**As**	**Be**	**Cr**	**Co**	**Cu**	**Tl**
025342-04	89-BH3-0-S-4	0-1.5	7700	2.9	<1	7.3	<10	5.7	<2.1
025343-04	89-BH5-8-S-4	8-9.5	5700	4.4	<1	6.6	<10	<5.2	<2.1
025346-04	89-BH8-3-S-4	3-4.5	12000	3.9	<1.1	12	<11	8.8	<2.2
025349-04	89-BH11-8-S-4	8-9.5	7200	2.9	<1.1	9.3	<11	<5.4	<2.1
025350-04	89-BH14-0-S-4	0-1.5	7200	3.2	<1.1	6.8	<11	<5.6	<2.2
025353-04	89-BH15-8-SO-4	8-9.5	7700	3.8	<1.1	28	<11	<5.3	<2.1
Practical Quantitation Limit			41-45	2.0-2.2	1-1.1	2.0-2.2	10.0-11.0	5.2-5.6	2.1-2.2
Site-Wide Background UTL/95th Percentile (Southwest Group)[a]			NA	4.4	0.65	15.9	5.2	18.2	<1.1
Quality Assurance/Quality Control (mg/l)									
025344-04	89-BH5-8-FB-4	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
025348-04	89-BH9-3-FB-4	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
025351-04	89-BH14-8-FB-4	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
025345-04	89-BH5-8-EB-4	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
025347-04	89-BH9-3-EB-4	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
025352-04	89-BH14-8-EB-4	NA	<0.2	<0.01	<0.005	<0.01	<0.05	<0.025	<0.01
Practical Quantitation Limit			0.2	0.01	0.005	0.01	0.05	0.025	0.01

[a]UTL/95th Percentile values taken from SNL/NM sitewide background report (IT Corporatoin 1996b).

Notes: mg/kg - milligrams per kilogram; **mg/l** - milligrams per liter; **NA** - not applicable; **TAL** - target analyte list; **UTL** - upper tolerance limit.

Metals: Al - aluminum; **As** - arsenic; **Be** - beryllium; **Cr** - chromium; **Co** - cobalt; **Cu** - copper; **Tl** - thallium.

Field Quality Control Samples

Three types of field quality control (QC) samples (Table 3-1) were collected for analyses during the investigation: field duplicate soil samples, field blank water samples, and equipment blank rinsate samples. No additional soils were collected for matrix spike/matrix spike duplicate analyses.

Five field duplicate soil samples were collected and composited, then split into the original and duplicate samples. These duplicate samples were submitted to the on-site laboratory and analyzed for HE, TAL metals, and gamma spectroscopy. One additional duplicate soil sample was submitted to the off-site laboratory and was analyzed for HE and TAL metals. The duplicate samples were non-detect for HE, below background levels for gamma spectroscopy, and either non-detect and/or very low concentrations for metals.

Four equipment blank rinsate samples were collected from deionized water poured over the equipment after decontamination of the sampling equipment. The samples were analyzed for HE and TAL metals by the off-site laboratory, and gamma spectroscopy by the on-site laboratory. The samples were non-detect for HE, below background levels for gamma spectroscopy, and either non-detect and/or very low concentrations for metals.

Four field blank water samples were exposed (open jar) to atmospheric conditions around the drilling/sampling operation and were analyzed for HE and TAL metals by the off-site laboratory, and gamma spectroscopy by the on-site laboratory. Trip blank samples are only collected and analyzed when sampling for volatile organic compounds (VOC). These four samples were not required, as VOCs were not included on the COC list for this site.

Data Validation Results

A review was performed to ensure that the DV1 and DV2 reviews are accurate and the data are acceptable for use in NFA reports (IT 1996a). The report is provided in Section 6.2. In summary, the review indicates that DV1 and DV2 findings are acceptable for the NFA report.

The analytical quality of the off-site laboratory metals data is exceptional for all analytes except antimony and aluminum. Laboratory control sample/laboratory control sample duplicate recovery values were below control limits for antimony and slightly above control limits for aluminum. Antimony was not detected in any soil samples, so the impact of the low recovery values on data quality is minimal. The aluminum recovery values may result in slightly over-estimated concentrations of that analyte. The remaining metal analytes had generally good agreement between the on-site laboratory and off-site laboratory data.

The off-site laboratory HE analytical quality data are generally good, but the practical quantitation limits are approximately an order of magnitude above the method detection limits for the on-site laboratory data. The laboratory QC values are considered acceptable for HE.

3.2.5.7 Data Evaluation

The data evaluation discussion will be limited to TAL metals. The gamma spectroscopy analytical data results were within normal SNL/NM background levels, and HE analytical results were non-detect except for three samples with trace amounts of RDX. Based on the analytical results, no evaluations were completed for radionuclides and HE.

Metal analytical results were compared to the site-wide background study for SNL/NM (IT 1996b) and the EPA proposed Subpart S action levels for soils (EPA 1990). For updated soil action levels, some values (i.e., zinc) were taken from the "Report of Generic Action Level Assistance for the Sandia National Laboratories/New Mexico Environmental Restoration Program" (IT Corporation 1994). The generic values from this report were made current for guidance through June 1994 according to RCRA proposed Subpart S methods.

Surface Soil Evaluation

The surface soil analytical results (both on-site and off-site laboratories) for metals were compared first to SNL/NM background levels and second to EPA proposed Subpart S action levels for soils (Table 3-6). The metals are within SNL/NM background levels and/or Subpart S action levels except for aluminum, arsenic, calcium, copper, iron, lead, magnesium, and potassium. Although calcium, iron, magnesium, and potassium were above background levels (or no background levels were available), these metals are considered essential nutrients (EPA 1989) and are not COCs for this site. The only metal (beryllium) specifically identified as a COC in the Work Plan (SNL/NM 1996) was found to be non-detect for all samples. Based on data evaluation and risk assessment criteria, aluminum, arsenic, copper, and lead provide the basis for conducting a human health risk assessment analysis

Subsurface Soil Evaluation

The subsurface soil analytical results (both on-site and off-site laboratories) for TAL metals were compared first to SNL/NM background levels and second to EPA proposed Subpart S action levels for soils (Table 3-7). The metals are within SNL/NM background levels and/or Subpart S action levels except for aluminum, arsenic, calcium, copper, iron, magnesium, and potassium. Although calcium, iron, magnesium, and potassium were above background levels (or no background levels were available), these metals are considered essential nutrients (EPA 1989) and are not COCs for this site. The only metal beryllium specifically identified as a COC in the Work Plan (SNL/NM 1996) was found to be non-detect for all samples. Based on data evaluation and risk assessment criteria, aluminum, arsenic, and copper provide the basis for conducting a human health risk assessment analysis.

3.3 Gaps in Information

The UXO/HE survey and soil sampling investigation was developed to address any data gap issues based on employee interviews, historical use of the area, and process knowledge of the site. No live and/or significant UXO/HE debris was found on the site. The soil sampling

TABLE 3-6

ER Site 89: Metal Data Comparison for Surface Soil Samples with SNL/NM Background Levels and Subpart S Action Levels

Compound	Number of Samples (On-Site)	Site 89 On-Site Laboratory Analytical Results Range of Values (mg/kg)	Number of Samples (Off-Site)	Site 89 Off-Site Laboratory Analytical Results Range of Values (mg/kg)	Site-Wide Background UTL/95th Percentile (mg/kg)	Subpart S Action Level (mg/kg)
Aluminum	22	3,900-15,000	5	9,400-22,000	NA	NA
Antimony	22	ND (10)	5	ND (12)	3.9	30
Arsenic	22	ND (50)	5	2.9-6.4	5.6	0.5
Barium	22	70-250	5	74-190	130	4,000
Beryllium	22	ND (3.4)	5	ND (1.0)	0.65	0.2
Cadmium	22	ND (20)	5	ND (1.0)	1.6	40
Calcium	22	4,000-65,000 (J)	5	13,000-38,000	NA	NA
Chromium	22	ND(10)	5	10.0-21.0	17.3	NA
Cobalt	22	ND (10)	5	ND (10)	5.2	NA
Copper	22	ND-24 (J)	5	7.4-36	15.4	NA
Iron	22	7,000-15,000	5	10,000-19,000	NA	NA
Lead	22	ND-490	5	7.2-42	21.4	400[a]
Magnesium	22	2,000-5,100	5	2,800-6,600	NA	NA
Manganese	22	160-430	5	170-400	NA	10,000[b]
Mercury	22	ND (0.06)	5	ND (0.11)	0.31	20
Nickel	22	ND (4.0)	5	ND-18	11.5	2,000
Potassium	22	NA	5	2,600-6,300	NA	NA
Selenium	22	ND (50)	5	ND (1.0)	<1	400[b]
Silver	22	ND (10)	5	ND (2.0)	2	200
Sodium	22	NA	5	ND (1,000)	NA	NA
Thallium	22	ND (200)	5	ND (2.0)	<1.1	NA
Vanadium	22	ND-19 (J)	5	18-31	20.4	600[b]
Zinc	22	20 (J)-51	5	28-57	62	20,000[b]

[a] The action level for lead is provided from U.S. Environmental Protection Agency, 1994. "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," PB94-963282, Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

[b] The action levels are provided from "Report of Generic Action Level Assistance for the Sandia National Laboratory/New Mexico Environmental Restoration Program," 1994, prepared by IT Corporation, Albuquerque, New Mexico.

NA = Not available

ND = Not detected

ND (50) = Not detected at this method detection limit (MDL)

TABLE 3-7
ER Site 89: Metal Data Comparison for Subsurface Soil Samples with SNL/NM Background Levels and Subpart S Action Levels

Compound	Number of Samples (On-Site)	Site 89 On-Site Laboratory Analytical Results Range of Values (mg/kg)	Number of Samples (Off-Site)	Site 89 Off-Site Laboratory Analytical Results Range of Values (mg/kg)	Site-Wide Background UTL/95th Percentile (mg/kg)	Subpart S Action Level (mg/kg)
Aluminum	33	1,800-10,000	6	5,700-12,000	NA	NA
Antimony	33	ND (10)	6	ND (13)	3.9	30
Arsenic	33	ND (50)	6	2.9-4.4	4.4	0.5
Barium	33	42-290	6	89-180	214	4,000
Beryllium	33	ND (3.4)	6	ND (1.1)	0.65	0.2
Cadmium	33	ND (20)	6	ND (1.1)	0.9	40
Calcium	33	19,000 (J)-62,000	6	38,000-60,000	NA	NA
Chromium	33	ND-81	6	6.6-28	15.9	NA
Cobalt	33	ND (10)	6	ND (11)	5.2	NA
Copper	33	ND (20)	6	ND-8.8	18.2	NA
Iron	33	3,200-12,000	6	6,600-11,000	NA	NA
Lead	33	ND-33 (J)	6	4.8-10	11.8	400[a]
Magnesium	33	1,700-12,000	6	2,500-5,500	NA	NA
Manganese	33	67-210	6	84-220	NA	10,000[b]
Mercury	33	ND-0.66	6	ND (0.11)	<0.1	20
Nickel	33	ND-85	6	ND-88	11.5	2,000
Potassium	33	NA	6	ND-2,700	NA	NA
Selenium	33	ND (50)	6	ND (1.1)	<1	400[b]
Silver	33	ND (10)	6	ND (2.1)	<1	200
Sodium	33	NA	6	ND (1,100)	NA	NA
Thallium	33	ND (200)	6	ND (2.1)	<1.1	NA
Vanadium	33	ND-18(J)	6	13-20	21.5	600[b]
Zinc	33	15 (J)-120	6	17-38	62	20,000[b]

[a] The action level for lead is provided from U.S. Environmental Protection Agency, 1994. "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," PB94-963282, Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.
[b] The action levels are provided from "Report of Generic Action Level Assistance for the Sandia National Laboratory/New Mexico Environmental Restoration Program," 1994, prepared by IT Corporation, Albuquerque, New Mexico.
NA=not available
ND=not detected
ND(50)=not detected above this method detection limit (MDL)

program provided the sampling, analyses, and evaluation of data for the areas at each end of the shock tubes where no data had been collected in the past. Based on the sampling program, all data gap issues were addressed in the field and in this report.

3.4 Risk Evaluation

The following subsections summarize the results of the risk assessment process for both human health and ecological risk related factors. The complete risk assessment report is provided in Section 6.3.

3.4.1 Human Health Risk Assessment

Site 89 has been recommended for industrial land use (DOE 1996b). Based on data evaluation (Section 3.2.5.7), a risk assessment was completed because several TAL metal results indicated detections above background and/or Subpart S action levels for soils. The risk assessment report provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site soil. The report calculated the hazard index and excess cancer risk for both industrial land-use and residential land-use (requested by the New Mexico Environment Department [NMED]). In addition, incremental risk numbers that are determined by subtracting risk associated with background from potential COC risk are discussed.

In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentrations reported from the on-site and off-site laboratories; subsurface and surface samples were combined into a single table to provide conservative risk calculations.

In summary, the Hazard Index calculated for the site COCs is 0.2, and the incremental hazard index is 0.22 for an industrial land-use setting, which is much less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). The cancer risk for the site COCs is 4×10^{-5}, and the incremental cancer risk is 3.2×10^{-5} for an industrial land-use setting, which is in the middle of the suggested range of acceptable risk of 10^{-6} and 10^{-4} (EPA 1989).

The residential land-use scenarios for this site are provided only for comparison in the risk assessment report. The report concludes that Site 89 does not have significant potential to affect human health under an industrial land-use setting.

3.4.2 Ecological Risk Assessment

The ecological risk assessment process is a screening level assessment. This assessment utilizes conservatism in the estimation of ecological risks. Potential risks were indicated for all these receptors (plant, deer mouse, and burrowing owl); however, the use of the maximum measured soil concentration or maximum detection limit to evaluate risk provided the "worst case" scenario for this assessment and may not reflect actual site conditions. However, based on further evaluation of detection limits, comparisons to background concentrations, toxicity benchmark values, and analytical data sets, it is concluded that ecological risks associated with the site are insignificant.

4.0 RATIONALE FOR NO FURTHER ACTION DECISION

Sixteen soil boring locations were drilled/sampled at the shock tube ends where the test vehicles exited (catch basin). Twenty surface soil samples were collected at the shock tube ends where the uncased explosives were fired. The data evaluation for the surface and subsurface soil samples shows no radionuclide or HE contamination, but some metal COCs were detected either above background levels, proposed Subpart S action levels, and/or the laboratory method detection limit.

Based on the field investigation data and the human risk assessment, an NFA is being recommended for Site 89 for the following reasons:

- No radioactivity above background levels was detected during the field screening program.
- Gamma spectroscopy results were all within background levels.
- HE analytical results were non-detect of RDX.
- No TAL metals were present in concentrations considered hazardous to human health for an industrial land-use setting.
- The screening level assessment concluded that ecological risks associated with the site are insignificant.

Based on the evidence cited above, Site 89 is proposed for an NFA based on DOU Criterion 5: The potential release site has been characterized in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land-use.

5.0 REFERENCES

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6.0 ANNEXES

6.1 Gamma Spectroscopy Results and Review

6.2 Data Validation Report

6.3 Risk Assessment Report

Section 6.3
Risk Assessment Report

ER SITE 89: RISK ASSESSMENT ANALYSIS

I. Site Description and History

ER Site 89 is the Shock Tube Site, and is included in Operable Unit 1335, Southwest Test Area. The site is located in the South Thunder Range, 1.6 miles west of the Solar Tower Facility and 0.6 miles southeast of Technical Area III, south of Magazine Road. The site covers approximately 2.25 acres. The site was operational from 1962 through the mid-1980's. In 1962, the site was established in the Thunder Range to support blast testing of reentry vehicles. The site was the location of the shock tube blast tests.

Blast testing included detonating an uncased explosive charge at one end of the tube to create a blast wave that sweeps over a target vehicle located at the tube's other end. Catch pits were constructed at the end of the shock tubes to provide a retrieval area for the target vehicles as they were ejected from the shock tube by the shock wave. After the test programs were completed in 1985, the site was abandoned. By 1996, all shock tubes were dismantled and removed from the site except for one section of the 19-foot diameter tube. The potential constituents of concern (COCs) are high explosive (HE), RCRA metals, beryllium, and depleted uranium (DU).

II. Human Health Risk Assessment Analysis

Risk assessment of this site includes a number of steps which culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include:

Step 1.	Site data are described which provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site.
Step 2.	Potential pathways by which a representative population might be exposed to the COCs are identified.
Step 3.	The potential intake of these COCs by the representative population is calculated using a tiered approach. The tiered approach includes screening steps, followed by potential intake calculations and a discussion or evaluation of the uncertainty in those calculations. Potential intake calculations are also applied to background screening data.
Step 4.	Data are described on the potential toxicity and cancer effects from exposure to the COCs and associated background constituents and subsequent intake.
Step 5.	Potential toxicity effects (specified as a Hazard Index) and cancer risks are calculated for COCs and background.
Step 6.	These values are compared with standards established by the United States (U.S.) Environmental Protection Agency (USEPA) to determine if further evaluation, and potential site clean-up, is required. COC risk values are also compared to background risk so that an incremental risk may be calculated.
Step 7.	Discussion of uncertainties in the previous steps.

II.1 Step 1. Site Data

Site history and characterization activities are used to identify potential COCs. The identification of COCs and the sampling to determine the concentration levels of those COCs across the site are described in the ER Site 89 No Further Action Proposal (NFA). In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. Maximum concentrations reported from the onsite and offsite laboratories subsurface and surface samples were combined into a single table to provide conservative risk calculations. The minimum UTL or 95th percentile, as appropriate, was selected to provide the background screen in Table 1 and to be used to calculate risk attributable to background in Table 4 Chemicals that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment (USEPA 1989). Only nonradioactive COCs are evaluated because all radiologicals were detected within normal background levels. The nonradioactive COCs evaluated are metals and explosives.

II.2 Step 2. Pathway Identification

ER Site 89 has been designated with a future land-use scenario of industrial (USDOE and USAF, 1996)(see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion. The inhalation pathway for chemicals is included because of the potential to inhale dust and volatiles. No contamination at depth was determined and therefore no water pathways to the groundwater are considered. Depth to groundwater at Site 89 is approximately 480 feet below ground surface. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered to not be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

PATHWAY IDENTIFICATION

Chemical Constituents
Soil Ingestion
Inhalation (Dust and volatiles)
Plant uptake (Residential only)

II.3 Steps 3-5. Calculation of Hazard Indices and Cancer Risks

Steps 3 through 5 are discussed in this section. These steps include the discussion of the tiered approach in eliminating potential COCs from further consideration in the risk assessment process and the calculation of intakes from all identified exposure pathways, the discussion of the toxicity information, and the calculation of the hazard indices and cancer risks.

The risks from the COCs at ER Site 89 were evaluated using a tiered approach. First, the maximum concentrations of COCs were compared to the SNL/NM background screening level for this area (IT, 1996). If a SNL/NM specific screening level was not available for a constituent, then a background value was obtained, when possible, from the U.S. Geological Survey (USGS) National Uranium Resource Evaluation (NURE) Program (USGS, 1994).

The maximum concentration of the each COC (surface and subsurface samples combined) was used in order to provide a conservative estimate of the associated risk. If any COCs were above the SNL/NM background screening levels or the USGS background value, all COCs were considered in further risk assessment analyses.

Second, if any COC failed the initial screening step, the maximum concentration for each COC was compared with the relevant action level calculated using methods and equations promulgated in the proposed Resource Conservation and Recovery Act (RCRA) Subpart S (40 CFR Part 264, 1990) and Risk Assessment Guidance for Superfund (RAGS) (USEPA, 1989) documentation. If there are 10 or fewer COCs and each has a maximum concentration less than one-tenth of the action level, then the site would be judged to pose no significant health hazard to humans. If there are more than 10 COCs, the Subpart S screening procedure was skipped.

Third, hazard indices and risk due to carcinogenic effects were calculated using Reasonable Maximum Exposure (RME) methods and equations promulgated in RAGS (USEPA, 1989). The combined effects of all COCs in the soils were calculated. The combined effects of the COCs at their respective background concentrations in the soils were also calculated. The most conservative background concentration between SNL/NM surface and subsurface concentration (minimum value of the 95th UTL or percentile concentration value, as applicable) was used in the risk calculation. For toxic compounds, the combined effects were calculated by summing the individual hazard quotients for each metal into a total Hazard Index. This Hazard Index is compared to the recommended standard of 1. For potentially carcinogenic compounds, the individual risks were summed. The total risk was compared to the recommended acceptable risk range of 10^{-4} to 10^{-6}.

II.3.1 Comparison to Background and Action Levels

ER Site 89 COCs (excluding HE) are listed in Table 1. The table shows the associated 95th percentile or UTL background levels (IT, 1996). The SNL/NM background levels have not yet been approved by the USEPA or the NMED but are the result of a comprehensive study of joint SNL/NM and U.S. Air Force data from the Kirtland Air Force Base (KAFB). The report was submitted for regulatory review in early 1996. The values shown in Table 1 supersede the background values described in an interim background study report (IT, 1994). Several compounds had maximum measured values greater than background screening levels.

Therefore all COCs were retained for further analysis with the exception of lead. The maximum concentration value for lead is 490 mg/kg. The USEPA intentionally does not provide any toxicological data on lead and therefore no risk parameter values can be calculated. However, EPA guidance for the screening value for lead for an industrial land-use scenario is 2000 mg/kg (USEPA, 1996a). The maximum concentration value for lead at this site is less than this screening value and therefore lead is eliminated from further consideration in this risk assessment. Because explosive compounds do not have calculated background values, this screening step was skipped, and all explosives are carried into the risk assessment analyses.

Because several COCs had concentrations greater than their respective SNL/NM background 95th percentile or UTL, the site fails the background screening criteria and all COCs proceed to the proposed Subpart S action level screening procedure. In addition, the ER Site 89 sample set had more than 10 COCs that continued past the first screening level, the proposed Subpart S screening process was skipped. All remaining COCs must have a Hazard Index value and cancer risk value calculated.

II.3.2 Identification of Toxicological Parameters

Table 2 shows the COCs that have been retained in the risk assessment and the values for the toxicological information available for those COCs.

II.3.3 Exposure Assessment and Risk Characterization

Section II.3.3.1 describes the exposure assessment for this risk assessment. Section II.3.3.2 provides the risk characterization including the Hazard Index value and the excess cancer risk for the potential COCs and associated background; industrial and residential land-uses.

Table 1. COCs at ER Site 89 and Comparison to the Background Screening Values.

COC name	Maximum concentration (mg/kg)	SNL/NM 95th % or UTL Level (mg/kg)	Is maximum COC concentration less than or equal to the applicable SNL/NM background screening value?
Arsenic	50 ND	4.4	**No**
Barium	290	130	**No**
Beryllium	3.4 ND	0.65	**No**
Cadmium	20 ND	0.9	**No**
Chromium, total*	81	1	**No**
Lead	490	11.8	**No**
Mercury	0.66	<0.1	**No^**
Selenium	50 ND	<1	**No^**
Silver	20 ND	<1	**No^**

ND - non-detect
^ - uncertainty due to detection limits
* total chromium assumed to be chromium VI (most conservative)

Table 2. Toxicological Parameter Values for ER Site 89 COCs

COC name	RfD_o (mg/kg/d)	RfD_{inh} (mg/kg/d)	Confidence	Sf_o (kg-d/mg)	Sf_{inh} (kg-d/mg)	Cancer Class ^
Arsenic	0.0003	--	M	1.5	15.1	A
Barium	0.07	0.000143	M	--	--	D
Beryllium	0.005	--	L	4.3	8.4	B2
Cadmium	0.0005	0.0000571	H	--	6.3	B1
Chromium, total*	0.005	--	L	--	42	A
Mercury	0.0003	0.0000857	M	--	--	D
Selenium	0.005	--	H	--	--	D
Silver	0.005	--	--	--	--	D
Trinitrotoluene	0.0005	--	M	0.03	--	C
RDX	0.003	--	--	0.11	--	--
HMX	0.05	--	--	--	--	--
PETN	--	--	--	--	--	--
NG	--	--	--	--	--	--

RfD_o - oral chronic reference dose in mg/kg-day
RfD_{inh} - inhalation chronic reference dose in mg/kg-day
Confidence - L = low, M = medium, H = high
SF_o - oral slope factor in $(mg/kg\text{-}day)^{-1}$
SF_{inh} - inhalation slope factor in $(mg/kg\text{-}day)^{-1}$
^ EPA weight-of-evidence classification system for carcinogenicity:

A - human carcinogen
B1 - probable human carcinogen. Limited human data are available
B2 - probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.
C - possible human carcinogen
D - not classifiable as to human carcinogenicity
E - evidence of noncarcinogenicity for humans

-- information not available
* total chromium assumed to be chromium VI (most conservative)

II.3.3.1 Exposure Assessment

Appendix 1 shows the equations and parameter values used in the calculation of intake values and the subsequent Hazard Index and excess cancer risk values for the individual exposure pathways. The appendix shows the parameters for both industrial and residential land-use scenarios. The equations are based on RAGS (USEPA, 1989). The parameter values are based on information from RAGS as well as other USEPA guidance documents and reflect the RME approach advocated by RAGS (USEPA, 1989).

Although the designated land-use scenario is industrial for this site, the risk values for a residential land-use scenario are also presented. These residential risk values are presented only to provide perspective on the potential for risk to human health under the more restrictive land-use scenario.

II.3.3.2 Risk Characterization

Table 3 shows that for the COCs, the Hazard Index value is 0.2 and the excess cancer risk is 4×10^{-5} for the designated industrial land-use scenario. The numbers presented included exposure from soil ingestion and dust and volatile inhalation for the COCs. Table 4 shows that for the ER Site 89 associated background constituents, the Hazard Index is 0.01 and the excess cancer risk is 4×10^{-6} for the designated industrial land-use scenario.

For the residential land-use scenario, the Hazard Index value increases to 39 and the excess cancer risk is 6×10^{-4}. The number presented included exposure from soil ingestion, dust and volatile inhalation and plant uptake. Although USEPA (1991) generally recommends that inhalation not be included in a residential land-use scenario, this pathway is included because of the potential for soil in Albuquerque, NM, to be eroded and, subsequently, for dust to be present even in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 4 shows that for the ER Site 89 associated background constituents, the Hazard Index increases to 1 and the excess cancer risk is 6×10^{-5}.

II.4 <u>Step 6 Comparison of Risk Values to Numerical Standards.</u>

The risk assessment analyses considered the evaluation of the potential for adverse health effects for both an industrial land-use scenario, which is the designated land-use scenario for this site, and also a residential land-use scenario.

Table 3. Risk Assessment Values for ER Site 89 COCs.

COC Name	Maximum concentration (mg/kg)	Industrial Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	50 ND	0.16	3E-5	2.86	6E-4
Barium	290	0.00	--	0.04	--
Beryllium	3.4 ND	0.00	6E-6	0.00	3E-5
Cadmium	20 ND	0.04	8E-9	16.35	1E-8
Chromium, total*	81	0.02	2E-7	0.06	3E-7
Mercury	0.66	0.00	--	1.14	--
Selenium	50 ND	0.01	--	17.59	--
Silver	10 ND	0.00	--	0.41	--
TNT	0.4 ND	0.00	5E-9	0.00	2E-8
RDX	0.75 ND	0.00	4E-8	0.00	1E-7
HMX	0.5 ND	0.00	--	0.00	--
PETN	0.75 ND	--	--	--	--
NG	0.15 ND	--	--	--	--
TOTAL		**0.2**	**4E-5**	**39**	**6E-4**

-- information not available
* total chromium assumed to be chromium VI (most conservative)

Table 4. Risk Assessment Values for ER Site 89 Background Constituents.

COC Name	Maximum concentration (mg/kg)	Industrial Land-Use Scenario		Residential Land-Use Scenario	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	4.4	0.01	3E-6	0.25	5E-5
Barium	130	0.00	--	0.02	--
Beryllium	0.65	0.00	1E-6	0.00	5E-6
Cadmium	0.9	0.00	4E-10	0.74	5E-10
Chromium, total*	1	0.00	3E-9	0.00	4E-9
Mercury	<0.1	--	--	--	--
Selenium	<1	--	--	--	--
Silver	<1	--	--	--	--
TOTAL		0.01	4E-6	1	6E-5

-- information not available
* total chromium assumed to be chromium VI (consistent with Table 3)

For the industrial land-use scenario, the Hazard Index calculated is 0.2; this is much less than the numerical standard suggested in RAGS (USEPA, 1989) of 1. The excess cancer risk is estimated at 4 x 10^{-5}. In RAGS, the USEPA suggests that a range of values (10^{-6} to 10^{-4}) be used as the numerical standard; the value calculated for this site is in the middle of the suggested acceptable risk range. Therefore, for an industrial land-use scenario, the Hazard Index risk assessment values are significantly less than the established numerical standards and the excess cancer risk is in the middle of the acceptable risk range. This risk assessment also determined risks considering background concentrations of the potential COCs for both the industrial and residential land-use scenarios. For the industrial land-use scenario, the Hazard Index is 0.01. The excess cancer risk is estimated at 4 x 10^{-6} . Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. These numbers are not rounded before the difference is determined and therefore may appear to be inconsistent with numbers presented in tables and discussed in the text. The incremental Hazard Index is 0.22 and the incremental cancer risk is 3.2 x 10^{-5} for the industrial land-use scenario.

For the residential land-use scenario, the calculated Hazard Index is 39, which is above the numerical guidance. The excess cancer risk is estimated at 6 x 10^{-4}; this value is above the suggested acceptable risk range. The hazard index for the associated background for the residential land-use scenario is 1. The excess cancer risk is estimated at 6 x 10^{-5}. For the residential land-use scenario, the incremental Hazard Index is 37.4 and the incremental cancer risk is 5.7 x 10^{-4}. The potential pathways considered for this calculation includes both soil ingestion, dust inhalation and plant uptake.

II.5 Step 7 Uncertainty Discussion

The data used to characterize Site 89, Shock Tube Site, was provided by collecting thirty-two subsurface soil samples from sixteen soil boring locations and twenty surface soil samples. Sample locations were determined by the placement of the five shock tubes. Three soil borings were located at the vehicle reentry end (catch basin) of each tube and four surface soil samples were located at the explosive end of each tube. This number of samples are deemed sufficient to establish whether COCs were detectable at the site. The COCs are HE, DU, RCRA metals and beryllium. DU was removed from the COC list (see Section II.1). Samples sent to the on-site laboratory were analyzed by the inductively coupled plasma method for metals, cold vapor atomic adsorption for mercury, and high performance liquid chromatography for HE. Samples sent to the off-site laboratory were analyzed by Methods 6010/7000/7471 for metals and Method 8330 for HE. The metal and HE data provided by the off-site laboratory is considered definitive data and suitable for use in the risk assessment. The analytical data (metals and HE) achieved the data quality objective of 100 percent on-site laboratory analysis with 20 percent off-site laboratory analysis for confirmation. In addition, the DV II data verification review stated the analytical data was acceptable for this NFA report.

The conclusion from the risk assessment analysis is that the potential effects caused by potential COCs on human health are small compared to established numerical standards for the industrial land-use scenario. Calculated incremental risk between potential COCs and associated background indicate small contribution of risk from the COCs when considering the industrial land-use scenario. It should also be noted that the risk values are driven by detection limit values, not actual reportable concentrations.

The potential effects on human health, for the COCs, are greater when considering the residential land-use scenario. Incremental risk between potential COCs and associated background also indicates a greater contribution of risk from the COCs. The increased effects on human health are primarily the result of including the plant uptake exposure pathway. Constituents that posed little to no risk considering an industrial land-use scenario (some of which are below background screening levels), contribute a significant portion of the risk associated with the residential land-use scenario. These constituents bioaccumulate in plants. Because ER Site 89 is designated as industrial land-use area (USDOE and USAF, 1996), the likelihood of significant plant uptake in this area is highly unlikely. The uncertainty in this conclusion is also considered to be small.

Because of the location, history of the site and the future land-use (USDOE and USAF, 1996), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis.

An RME approach was used to calculate the risk assessment values, which means that the parameter values used in the calculations were conservative and that the calculated intakes are likely overestimates. Maximum measured values of the concentrations of the COCs and minimum value of the 95th UTL or percentile background concentration value, as applicable, of background concentrations associated with the COCs were used to provide conservative results.

Table 2 shows the uncertainties (confidence) in the toxicological parameter values. There is a mixture of estimated values and values from the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1996b) and Integrated Risk Information System (IRIS) (USEPA, 1988, 1994) databases. Where values are not provided, information is not available from HEAST, IRIS, or USEPA regions. The constituents without toxicological parameters have low concentrations and are judged to be insignificant contributors to the overall risk. Because of the conservative nature of the RME approach, the uncertainties in the toxicological values are not expected to be of high enough concern to change the conclusion from the risk assessment analysis.

The risk assessment values are low for the industrial land-use scenario compared to the established numerical standards. Though the residential land-use Hazard Index and excess cancer risk are above the numerical standard, it has been determined that future land-use at this locality will not be residential (USDOE and USAF, 1996). The overall uncertainty in all of the steps in the risk assessment process is therefore considered insignificant with respect to the conclusion reached.

II.6 Summary

The Shock Tube Site, ER Site 89, had relatively minor contamination consisting of some inorganic and explosive compounds. Because of the location of the site on KAFB, the designated industrial land-use scenario (USDOE and USAF, 1996) and the nature of the contamination, the potential exposure pathways identified for this site included soil ingestion and dust and volatile inhalation for chemical constituents.

The residential land-use scenario includes the soil ingestion, inhalation, and plant uptake exposure pathways. Because the site is designated as industrial

(USDOE and USAF, 1996) and the residential land-use scenario is presented to only provide perspective, the stated exposure pathways were included but provide a conservative risk assessment.

Using conservative assumptions and employing a RME approach to the risk assessment, the calculations for the COCs show that for the industrial land-use scenario the Hazard Index (0.2) is significantly less than the accepted numerical guidance from the USEPA. The estimated cancer risk (4×10^{-5}) is in the middle of the suggested acceptable risk range. The incremental Hazard Index is 0.22 and the incremental cancer risk is 3.2×10^{-5} for the industrial land-use scenario. Incremental risk calculation indicate that insignificant contribution to risk from the COCs considering an industrial land-use scenario. It should also be noted that the risk values are driven by detection limit values, not actual reportable concentrations.

The calculations for the COCs show that for the residential land-use scenario the Hazard Index (39) is above the accepted numerical guidance from the USEPA. The estimated cancer risk (6×10^{-4}) is above the suggested acceptable risk range. The majority of the risk is associated with the inclusion of the plant uptake exposure pathway. Constituents that posed little to no risk considering an industrial land-use scenario (some of which are below background screening levels), contribute a significant portion of the risk associated with the residential land-use scenario. These constituents bioaccumulate in plants. Because ER Site 89 is an industrial site, the likelihood of significant plant uptake in this area is highly unlikely. For the residential land-use scenario, the incremental Hazard Index is 37.4 and the incremental cancer risk is 5.7×10^{-4}. Contribution of risk from the COCs was evident considering residential land-use, due to the plant uptake exposure pathway, but future use will be restricted to industrial land-use.

The uncertainties associated with the calculations are considered small relative to the conservativeness of the risk assessment analysis. It is therefore concluded that this site does not have significant potential to affect human health under an industrial land-use scenario.

III. Ecological Risk Assessment

III.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPECs) in soils from ER Site 89. The ecological risk assessment process performed for this site is a screening level assessment which follows the methodology presented in IT (1997) and SNL/NM (1997). The methodology was based on screening level guidance presented by USEPA (USEPA, 1992; 1996c; 1996d) and by Wentsel, et al. (1996) and is consistent with a phased approach. This assessment utilizes conservatism in the estimation of ecological risks, however, ecological relevance and professional judgment are also incorporated as recommended by USEPA (1996c) and Wentsel et al., (1996) to insure that the predicted exposures of selected ecological receptors reasonably reflect those expected to occur at the site.

III.2 Ecological Pathways

The area of ER Site 89 consists of a disturbed soil surface surrounded by desert grassland vegetation. The topography is flat and there are no major drainages or surface water features in the area. The South Thunder Range lies in an internal drainage basin; therefore, off-site surface water drainage is not connected to the Rio Grande. Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil. No threatened, endangered, or other special status species are known to occur at the site. Scattered individuals of the grama grass cactus (Pediocactus papyracanthus) occur in the grassland habitats of the South Thunder Range (Sullivan and Knight, 1994; IT, 1995). This species had once been listed as endangered by the New Mexico Forestry and Resource Conservation Division (NMFRCD) and as a C2 candidate for federal listing by the U.S. Fish and Wildlife Service, but has since been removed from both special status categories by the respective agencies. A population of the Santa Fe milkvetch (Astragalus feensis), designated a rare and sensitive plant by the NMFRCD, occurs on the low hills about 0.5 mile north of the site (Sullivan and Knight, 1994), but is not expected to occur at the site due to its affinity to the limestone-derived soils of these hills.

III.3 Constituents of Potential Ecological Concern

The COCs at this site are HE, metals (particularly beryllium), and DU. Following the screening process used for the selection of potential COCs for the human health risk assessment, the inorganic COCs were screened against background UTLs. Nine inorganic analytes, arsenic, barium, beryllium, cadmium, chromium (total), lead, mercury, selenium and silver, were identified as COPECs at ER Site 89. Four of these (beryllium, cadmium, selenium, and silver) were not detected in either surface or subsurface samples; however, the detection limits exceeded the upper tolerance limits of the background soil concentrations, and therefore, these analytes could not be excluded from the list of COPECs. HE compounds were not detected, and radiological field screening and gamma spectroscopy results were within the normal background range.

III.4 Receptors and Exposure Modeling

A non-specific perennial plant was used as the receptor to represent plant species at the site. Two wildlife receptors (deer mouse and burrowing owl) were used to represent wildlife use of the site. Exposure modeling for the wildlife receptors was limited to the food ingestion pathway. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion. Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled as an omnivore (50 percent of the diet as plants and 50 percent as soil invertebrates) and the burrowing owl as a strict predator on small mammals (100 percent of the diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 5 presents the species-specific factors used in modeling exposures in the wildlife receptors. Although home range is also included in this table, exposures for this screening-level assessment were modeled using an area use factor of 1, implying that all food items and soil ingested are from the site being investigated.

The maximum measured COPEC concentrations from both surface and subsurface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site. In the case of arsenic, the detection limit from the on-site laboratory exceeded the measured concentrations of arsenic from the off-site laboratory. Therefore, the detection limit from the on-site laboratory was used as the maximum arsenic concentration in soil at this site. Detection limits from the on-site laboratory were also used for beryllium, cadmium, selenium, and silver, which were not otherwise detected but were retained due to the high detection limit.

Table 5. Exposure Factors for Ecological Receptors at Environmental Restoration Site 89, Sandia National Laboratories, New Mexico

Receptor species	Class/Order	Trophic level	Body weight (kg)[a]	Food intake rate (kg/d)[b]	Dietary Composition[c]	Home range (acres)
Deer Mouse (Peromyscus maniculatus)	Mammalia/ Rodentia	Omnivore	0.0239[d]	0.00372	Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake)	0.27[e]
Burrowing owl (Speotyto cunicularia)	Aves/ Strigiformes	Carnivore	0.155[f]	0.0173	Rodents: 100% (+ Soil at 2% of intake)	34.6[g]

[a]Body weights are in kilograms wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.
[d]From Silva and Downing (1995).
[e]From USEPA (1993), based on the average home range measured in semi-arid shrubland in Idaho.
[f]From Dunning (1993).
[g]From Haug et al. (1993).

Table 6 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 7 presents the maximum concentrations of COPECs in soil, the derived concentrations in the various food-chain elements, and the modeled dietary exposures for each of wildlife receptor species.

III.5 Toxicity Benchmarks

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 8. For plants, the benchmark soil concentrations are based on the Lowest-Observed-Adverse-Effect-Level (LOAEL) with the adverse effect being a 20% reduction of growth. For wildlife, the toxicity benchmarks are based on the No-Observed-Adverse-Effect-Level (NOAEL) for chronic oral exposure (with emphasis on reproductive effects) in a taxonomically similar test species. Total chromium was assumed to be primarily composed of Cr+3 and mercury in these soils was assumed to be inorganic in form. Insufficient toxicity information was found to estimate the NOAEL for beryllium in birds.

III.6 Risk Characterization

The maximum soil concentrations and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. The results of these comparisons are presented in Table 9. Hazard quotients (HQs) are used to quantify the comparison with the benchmarks for wildlife exposure. Maximum soil concentrations for all COPECs except barium and beryllium exceeded their respective plant benchmark concentrations. In the deer mouse, HQs exceeded unity for arsenic (HQ = 31.5), barium (HQ = 2.69), and selenium (HQ = 15.3). In the burrowing owl, only the HQ for selenium (HQ = 3.30) exceeded unity.

Table 6. Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at Environmental Restoration Site 89, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Arsenic	4.00×10^{-2} [a]	1.00×10^{0} [b]	2.00×10^{-3} [a]
Barium	1.50×10^{-1} [a]	1.00×10^{0} [b]	2.00×10^{-4} [c]
Beryllium	1.00×10^{-2} [a]	1.00×10^{0} [b]	1.00×10^{-3} [a]
Cadmium	5.50×10^{-1} [a]	6.00×10^{-1} [d]	5.50×10^{-4} [a]
Chromium	4.00×10^{-2} [e]	1.30×10^{-1} [f]	3.00×10^{-2} [e]
Lead	9.00×10^{-2} [e]	4.00×10^{-2} [d]	8.00×10^{-4} [a]
Mercury	1.00×10^{0} [e]	1.00×10^{0} [b]	2.50×10^{-1} [a]
Selenium	5.00×10^{-1} [e]	1.00×10^{0} [b]	1.00×10^{-1} [e]
Silver	1.00×10^{0} [e]	2.50×10^{-1} [d]	5.00×10^{-3} [e]
HMX	2.74×10^{1} [g]	1.36×10^{1} [h]	3.42×10^{-8} [g]
PETN	2.78×10^{-1} [g]	2.02×10^{1} [h]	1.25×10^{-7} [g]
RDX	1.22×10^{1} [g]	1.45×10^{1} [h]	1.46×10^{-7} [g]
2,4,6-trinitrotoluene	4.60×10^{0} [g]	1.58×10^{1} [h]	8.28×10^{-7} [g]
nitroglycerin	4.48×10^{0} [g]	1.59×10^{1} [h]	8.68×10^{-6} [g]

[a]From Baes et al. (1984).
[b]Default value.
[c]From IAEA (1994).
[d]From Stafford et al. (1991).
[e]From NCRP (1989).
[f]From Ma (1982).
[g]From equations developed in Travis and Arms (1988).
[h]From equations developed in Connell and Markwell (1990).

Table 7. Media Concentrations for Constituents of Potential Ecological Concern at Environmental Restoration Site 89, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Surface Soil [a] (maximum)	Plant [a,b] Foliage	Soil[a,b] Invertebrate	Deer Mouse Tissues[a,c]
Arsenic	5.00×10^{1}	2.00×10^{0}	5.00×10^{1}	1.69×10^{-1}
Barium	2.50×10^{2}	4.35×10^{1}	2.90×10^{2}	1.08×10^{-1}
Beryllium	3.40×10^{0}	3.40×10^{-2}	3.40×10^{0}	5.58×10^{-3}
Cadmium	2.00×10^{1}	1.10×10^{1}	1.20×10^{1}	2.05×10^{-2}
Chromium	8.10×10^{1}	3.24×10^{0}	1.05×10^{1}	7.97×10^{-1}
Lead	4.90×10^{2}	4.41×10^{0}	1.96×10^{1}	1.04×10^{-1}
Mercury	1.10×10^{-1}	1.10×10^{-1}	1.10×10^{-1}	8.77×10^{-2}
Selenium	5.00×10^{1}	2.50×10^{1}	5.00×10^{1}	1.20×10^{1}
Silver	2.00×10^{1}	2.00×10^{1}	5.00×10^{0}	2.01×10^{-1}
HMX	5.00×10^{-1}	1.37×10^{1}	6.78×10^{0}	1.09×10^{-6}
PETN	7.50×10^{-1}	2.08×10^{-1}	1.51×10^{1}	3.00×10^{-3}
RDX	7.50×10^{-1}	9.12×10^{0}	1.09×10^{1}	4.57×10^{-6}
2,4,6-trinitrotoluene	4.00×10^{-1}	1.84×10^{0}	6.33×10^{0}	1.06×10^{-5}
nitroglycerin	1.50×10^{-1}	6.73×10^{-1}	2.38×10^{0}	4.14×10^{-6}

[a]Milligrams per kilogram. All are based on dry weight of the media.

[b]Product of the soil concentration and the corresponding transfer factor.

[c]Product of the average concentration in food times the food-to-muscle transfer factor times the wet weight-dry weight conversion factor of 3.125 (from USEPA, 1993).

Table 8. Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 89, Sandia National Laboratories, New Mexico

		Mammalian NOAELs (mg/kg/d)			Avian NOAELs (mg/kg/d)		
Constituent of Potential Ecological Concern	Plant Benchmark[a] (mg/kg)	Mammalian Test Species[b]	Test Species NOAEL[c]	Deer Mouse NOAEL[d]	Avian Test Species[e]	Test Species NOAEL[e]	Burrowing Owl NOAEL[f]
Arsenic	10	Lab mouse	0.126	0.133	Mallard	5.14	5.14
Barium	500	Lab rat	5.1	9.98	Chicks	20.8	20.8
Beryllium	10	Lab rat	0.66	1.29	---	---	---
Cadmium	3	Lab rat[g]	1	1.89	Mallard	1.45	1.45
Chromium	1	Lab rat	2,737	5,350	Black duck	1.00	1.00
Lead	50	Lab rat	8	15.6	American kestrel	3.85	3.85
Mercury	0.3	Mink	1	2.54	Japanese quail	0.45	0.45
Selenium	1	Lab rat	0.2	0.391	Screech owl	0.44	0.44
Silver	2	Lab rat[h]	17.8[h]	34.8	---	---	---
HMX	---	Lab rat	10[h]	19.6	---	---	---
PETN	---	Lab mouse	5870[i]	6213	---	---	---
RDX	---	Lab rat	0.3[h]	0.587	---	---	---
2,4,6-trinitrotoluene	30	Lab rat	1.6[j]	3.06	---	---	---
nitroglycerin	---	Lab mouse	96.4[k]	102	---	---	---

[a]From Will and Suter (1995).
[b]From Sample et al. (1996), except where noted. Body weights (in kilograms) for NOAEL conversion are: lab mouse, 0.030; lab rat, 0.350 (except where noted, for cadminum, 0.303); and mink, 1.0.
[c]From Sample et al. (1996), except where noted.
[d]Based on NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.239 kilograms and a mammalian scaling factor of 0.25.
[e]From Sample et al. (1996).
[f]Based on NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
[g]Body weight 0.303 kilograms, based on study data (Sample et al., 1996).
[h]From USEPA (1997).
[i]Based on an LD_{50} of 7,000 mg/kg in mice (RTECS, 1997) and conversion to NOAEL using nitroglycerin as a chemical analog with LD_{50} of 115 mg/kg (RTECS, 1997) and NOAEL of 96.4 mg/kg/day in mice (Smith, 1986).
[j]From Talmage and Opresko (1995).
[k] From Smith (1996).

Table 9. Comparisons to Toxicity Benchmarks for Ecological Receptors at Environmental Restoration Site 89, Sandia National Laboratories, New Mexico

Constituent of Potential Ecological Concern	Plant Hazard Quotient	Deer Mouse Hazard Quotient	Burrowing Owl Hazard Quotient
Arsenic	**5.00×10^{0}**	**3.15×10^{1}**	2.53×10^{-2}
Barium	5.00×10^{-1}	**2.32×10^{0}**	2.73×10^{-2}
Beryllium	3.40×10^{-1}	2.15×10^{-1}	---[b]
Cadmium	**6.67×10^{0}**	9.82×10^{-1}	3.23×10^{-2}
Chromium	**8.10×10^{1}**	2.47×10^{-4}	2.69×10^{-1}
Lead	**9.80×10^{0}**	4.14×10^{-1}	2.87×10^{-1}
Mercury	3.67×10^{-1}	2.98×10^{-2}	3.94×10^{-3}
Selenium	**5.00×10^{1}**	**1.53×10^{1}**	**3.30×10^{0}**
Silver	**5.00×10^{0}**	5.77×10^{-2}	---
HMX	---	8.15×10^{-2}	---
PETN	---	1.92×10^{-4}	---
RDX	---	**2.66×10^{0}**	---
2,4,6-trinitrotoluene	1.33×10^{-2}	2.08×10^{-1}	---
nitroglycerin	---	1.25×10^{-2}	---

Bold text indicates hazard quotient greater than one.
[b] ---Information not available.

III.7 Uncertainties

Many uncertainties are associated with the characterization of ecological risks at ER Site 89. These uncertainties result in the use of assumptions in estimating risk which may lead to an overestimation or underestimation of the true risk presented at a site. For this screening level risk assessment, assumptions are made that are more likely to overestimate risk rather than to underestimate it. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of the maximum measured soil concentration or maximum detection limit to evaluate risk, the use of wildlife toxicity benchmarks based on NOAEL values, the use of maximum transfer factors found in the literature for modeling plant and mouse tissue concentrations, the use earthworm-based transfer factors or a default factor of 1.0 for modeling COPECs into soil invertebrates, and the use of 1.0 as the use factor for wildlife receptors regardless of seasonal use or home range size.

III.8 Summary

Potential risks were indicated for all three ecological receptors at ER Site 89; however, the use of the maximum measured soil concentration or maximum detection limit to evaluate risk provided the "worst case" scenario for the risk assessment and may not reflect actual site conditions. The higher detection limits from the on-site lab were used to evaluate risk for arsenic, beryllium, cadmium, selenium, silver, and all HE compounds. Screening level predictions indicated no ecological risks associated with exposure to beryllium, TNT, HMX, PENT, or nitroglycerin.

Exposure estimated conducted with maximum detection limits from the on-site laboratory are very likely to have resulted in over estimations of actual risk. The higher arsenic detection limit (50 mg/kg) from the on-site laboratory resulted in HQs of 5 and 31.5 for the plant and the deer mouse, respectively. The maximum detected arsenic concentration reported by the off-site lab for ER Site 89 was 6.4 mg/kg with an average of 4.2 mg/kg which is within the soil background range of 5.6 mg/kg for surface soils. Arsenic is, therefore not an ecological concern at ER Site 89. Similar comparisons can be made with cadmium, selenium, and silver. The detection limit for cadmium reported by the on-site laboratory (20 mg/kg) resulted in a HQ of 6.7 for the plant. The detection limit for cadmium reported by the off-site laboratory (1 mg/kg) was, however, within the background soil range. The higher selenium detection limit (50 mg/kg) from the on-site lab resulted in HQs of 50 for the plant and 15.3 for the deer mouse. However, the detection limit of the off-site lab (1 mg/kg) was within the range of the soil background concentrations for selenium. The on-site laboratory detection limit for silver (10 mg/kg) resulted in a HQ of 5.0 for the plant. The detection limit for silver from the off-site laboratory (2 mg/kg) was within the range of the soil background. For arsenic, cadmium, selenium, and silver, the maximum detection limits or measured concentrations reported by the off-site laboratory can be viewed as confirmatory analysis that supports the unlikelihood that these chemicals are of potential ecological risk.

The detection limit (0.75 mg/kg) reported for RDX resulted in a HQ of 2.66 for the deer mouse. No other receptors were predicted to be at risk following exposure to this compound. Because this screening benchmark value was based on a NOAEL with the toxicological endpoint being the inflammation of the prostate and not a reproductive endpoint, it is very likely that the benchmark used is an overestimate of potential adverse effects which may occur at the population level. Taking into consideration the use of the maximum detection limit and a very conservative toxicological benchmark in the estimation of risk associated with RDX, it is highly unlikely that RDX is an ecological concern at ER Site 89.

Detected concentrations of barium, chromium, and lead resulted in prediction of ecological risk. The maximum detected barium concentration in surface soils (250 mg/kg) produced a HQ of 2.32 for the deer mouse. The average site concentration from 27 data surface soil points was 92 mg/kg which is within the range of background surface soil concentrations (130 mg/kg) for barium. Barium is, therefore, not predicted to be of ecological concern at ER Site 89. A similar comparison can be made with chromium. The maximum measured surface soil chromium concentration for ER Site 89 was 21 mg/kg which resulted in a HQ of 81 for the plant. However, out of the 27 data points for the site, 22 were below the off-site laboratory detection limit of 10 mg/kg and four were below 17 mg/kg which is the soil background value. It is reasonable to conclude that chromium in Site 89 is not an ecological hazard. The analytical results for lead in soil were: 490 mg/kg , 48 mg/kg , 40 mg/kg, five data points with J values (<20 mg/kg) and 13 data points below the off-site laboratory detection limit (<10 mg/kg). The maximum concentration of 490 mg/kg resulted in a HQ of 9.8. Based on this data set, it is possible that the 490 mg/kg is an anomaly. Use of a more realistic exposure concentration such as the 95% UTL or average concentration would result in a HQ below unity. Therefore, lead is not an ecological concern in Site 89.

Overall, based on further evaluation of detection limits, comparisons to background concentrations, toxicity benchmark values, and analytical data sets, it is concluded that ecological risks associated with ER Site 89 are insignificant. The greatest uncertainty in this screening assessment is that associated with the analytical detection limits.

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APPENDIX 1.

Sandia National Laboratories Environmental Restoration Program

EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

BACKGROUND

Sandia National Laboratories (SNL) proposes that a default set of exposure routes and associated default parameter values be developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM ER sites have similar types of contamination and physical settings, SNL believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the USEPA Region VI and NMED, SNL proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all Environmental Restoration sites exist within the boundaries of the Kirtland AFB. Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/ER draft Environmental Assessment (DOE, 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land use scenarios for the SNL/NM ER sites. At this time, all SNL/NM ER sites have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based on a residential land use scenario. All three land use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent hazard index, risk and dose values. EPA (EPA, 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water;
- Ingestion of contaminated soil;

- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products;
- Ingestion of contaminated surface water while swimming;
- Dermal contact with chemicals in water;
- Dermal contact with chemicals in soil;
- Inhalation of airborne compounds (vapor phase or particulate), and;
- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based on the location of the SNL ER sites and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM ER sites, there does not presently occur any consumption of fish, shell fish, fruits, vegetables, meat, eggs, or dairy products that originate on-site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL, 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land use scenarios, SNL/NM ER has therefore excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM ER site:

- Ingestion of contaminated fish and shell fish;
- Ingestion of contaminated fruits and vegetables;
- Ingestion of contaminated meat, eggs, and dairy products; and
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land-use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based on this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

Table 1. Exposure Pathways Considered for Various Land Use Scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact	Dermal contact	Dermal contact
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	Ingestion of fruits and vegetables
		External exposure to penetrating radiation from ground surfaces

EQUATIONS AND DEFAULT PARAMETER VALUES FOR IDENTIFIED EXPOSURE ROUTES

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA, 1989a and 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL, 1993). Also shown are the default values SNL/NM ER suggests for use in Reasonable Maximum Exposure (RME) risk assessment calculations for industrial, recreational, and residential scenarios, based on EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL, 1993).

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., Hazard Quotient/Index, excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \quad (1)$$

where

C	= contaminant concentration (site specific);
CR	= contact rate for the exposure pathway;
EFD	= exposure frequency and duration;
BW	= body weight of average exposure individual;
AT	= time over which exposure is averaged.

The total risk/dose (either cancer risk or hazard index) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of 10^{-4} to 10^{-6}. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the Hazard Index) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard Hazard Index of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA, 1989) and the RESRAD Manual (ANL, 1993). Table 2 shows the default parameter values suggested for used by SNL at ER sites, based on the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are

Table 2. Default Parameter Values for Various Land Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure frequency (d/y)	***	***	***
Exposure duration (y)	30[a,b]	30[a,b]	30[a,b]
Body weight (kg)	70[a,b]	56[a,b]	70 adult[a,b] 15 child
Averaging Time (days) for carcinogenic compounds (=70 y x 365 d/y) for noncarcinogenic compounds (=ED x 365 d/y)	25550[a] 10950	25550[a] 10950	25550[a] 10950
Soil Ingestion Pathway			
Ingestion rate	100 mg/d[c]	6.24 g/y[d]	114 mg-y/kg-d[a]
Inhalation Pathway			
Inhalation rate (m^3/yr)	5000[a,b]	146[d]	5475[a,b,d]
Volatilization factor (m^3/kg)	chemical specific	chemical specific	chemical specific
Particulate emission factor (m^3/kg)	1.32E9[a]	1.32E9[a]	1.32E9[a]
Water Ingestion Pathway			
Ingestion rate (L/d)	2[a,b]	2[a,b]	2[a,b]
Food Ingestion Pathway			
Ingestion rate (kg/yr)	NA	NA	138[b,d]
Fraction ingested	NA	NA	0.25[b,d]
Dermal Pathway			
Surface area in water (m^2)	2[b,e]	2[b,e]	2[b,e]
Surface area in soil (m^2)	0.53[b,e]	0.53[b,e]	0.53[b,e]
Permeability coefficient	chemical specific	chemical specific	chemical specific

*** The exposure frequencies for the land use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land use scenario is 8 h/d for 250 d/y; for the recreational land use, a value of 2 hr/wk for 52 wk/y is used (EPA, 1989b); for a residential land use, all contact rates are given per day for 350 d/y.

[a] RAGS, Vol 1, Part B (EPA, 1991).

[b] Exposure Factors Handbook (EPA, 1989b)

[c] EPA Region VI guidance.

[d] For radionuclides, RESRAD (ANL, 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

[e] Dermal Exposure Assessment, 1992.

suggested for use for the various exposure pathways based on the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land-use scenario. There are no current residential land-use designations at SNL ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land-use, SNL will provide risk parameter values based on a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on Sandia ER sites. The parameter values are based on EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

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October 13, 2003

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